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LUNAR ORBIT RENDEZVOUS REFERENCE TRAJECTORY DATA PACKAGE (U)

PREPARED UNDER CONTRACT NO. 10001
TO BELLCOMM, INC.

MIDCOURSE SENSITIVITIES AND GUIDANCE ANALYSIS COEFFICIENTS

Classification changed to
~~UNCLASSIFIED~~ by authority of
 SCG-11, Rev. 1, 1/1/66, and
 SCG-6, 8/27/64 as amended
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1.0 INTRODUCTION AND SUMMARY

In accordance with a Bellcomm Incorporated request, Space Technology Laboratories, Inc. is submitting under separate document the midcourse sensitivities and guidance analysis coefficients for the LOR RTDP Issue 2 trajectory.

Section 2 of this document contains the necessary definitions and equations to fully explain the numerical data which is presented in Section 3. For the translunar trajectory, the midcourse sensitivities have been computed for the distance of closest approach, the inclination of the incoming hyperbola, and time of flight. The parameters which are used for the transearth phase of the trajectory are the time of flight and the "parameter of the orbit" resolved in the STR system. The complete description of this system has been included in Section 2.

In addition to the numerical data which is presented in matrix form, the sensitivity coefficients have been plotted and are presented in Figures 3.1-1 to 3.1-18. These data represent the first 18 hours of translunar and transearth flight for the reference trajectory of Issue 2.

2.0 DEFINITIONS AND EQUATIONS

General Description

The assumption which is generally made is that the dependence of the three dimensional miss vector, $\vec{\Delta M}$, upon the midcourse velocity, $\vec{\Delta V}$, can be approximated by a linear relation,

$$\vec{\Delta M} = -K_v \vec{\Delta V}$$

For the purpose of guidance analysis, it is assumed that the dependence of the miss vector upon the injection error vector, $\vec{\delta X}_0$, can also be approximated by a linear relation,

$$\vec{\Delta M} = K \vec{\delta X}$$

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Both of the above assumptions invoke first order perturbation theory.

The miss vector has components, $\Delta\mu_1$, $\Delta\mu_2$, $\Delta\mu_3$; the midcourse velocity vector components are $\Delta\dot{x}_m$, $\Delta\dot{y}_m$, $\Delta\dot{z}_m$ and the injection error vector has components of position and velocity as follows

$$\delta X_o = \begin{pmatrix} \delta x_o \\ \delta y_o \\ \delta z_o \\ \delta \dot{x}_o \\ \delta \dot{y}_o \\ \delta \dot{z}_o \end{pmatrix}$$

Midcourse Sensitivity Coefficients

The K matrix is the matrix of midcourse sensitivities and is defined as

$$K = \begin{bmatrix} \frac{\partial \mu_1}{\partial x_m} & \frac{\partial \mu_1}{\partial y_m} & \frac{\partial \mu_1}{\partial z_m} & \frac{\partial \mu_1}{\partial \dot{x}_m} & \frac{\partial \mu_1}{\partial \dot{y}_m} & \frac{\partial \mu_1}{\partial \dot{z}_m} \\ \frac{\partial \mu_2}{\partial x_m} & \frac{\partial \mu_2}{\partial y_m} & \frac{\partial \mu_2}{\partial z_m} & \frac{\partial \mu_2}{\partial \dot{x}_m} & \frac{\partial \mu_2}{\partial \dot{y}_m} & \frac{\partial \mu_2}{\partial \dot{z}_m} \\ \frac{\partial \mu_3}{\partial x_m} & \frac{\partial \mu_3}{\partial y_m} & \frac{\partial \mu_3}{\partial z_m} & \frac{\partial \mu_3}{\partial \dot{x}_m} & \frac{\partial \mu_3}{\partial \dot{y}_m} & \frac{\partial \mu_3}{\partial \dot{z}_m} \end{bmatrix}$$

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where $x_m, y_m, z_m, \dot{x}_m, \dot{y}_m, \dot{z}_m$ are the position and velocity at the specific midcourse time, t_m . The desired terminal parameters for which the midcourse is performed are μ_1, μ_2 and μ_3 . μ_1 can be any parameter such as B · T, B · R, inclination of the target centered orbit, impact velocity, time of flight, distance of closest approach and so forth. The parameters usually used for midcourse calculations are those which relate the impact parameter and time of flight to midcourse velocity correction. In this case then,

$$\mu_1 = B \cdot T$$

$$\mu_2 = B \cdot R$$

and

$$\mu_3 = T_f$$

The choice of the parameters to be used is, to a large extent, dictated by the linearity assumptions previously mentioned.

The K_v matrix is the right hand 3×3 matrix of the K matrix, and is used to establish the required midcourse correction as well as the critical plane correction.

The critical plane is defined as

$$\vec{M}_1 \times \vec{M}_2$$

where \vec{M}_1 and \vec{M}_2 are gradient vectors in velocity space, thus

$$\vec{M}_1 = \nabla_v \mu_1$$

and

$$\vec{M}_2 = \nabla_v \mu_2$$

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The normal to the critical plane is then

$$\vec{N} = \frac{\vec{M}_1 \times \vec{M}_2}{|\vec{M}_1 \times \vec{M}_2|}$$

and the components of midcourse velocity in the critical plane are obtained as

$$\Delta \vec{V}_c = \Delta \vec{V} - (\Delta \vec{V} \cdot \vec{N}) \vec{N}$$

Guidance Analysis Coefficients

The G matrix is the matrix of guidance analysis coefficients. This matrix relates injection errors to midcourse velocity corrections required by a specific guidance logic. This is made apparent by the mathematical definition of the G matrix which is

$$G_T = -K_v^{-1} K_o$$

The elements of this matrix consist of the following partials

$$\begin{bmatrix} \frac{\partial \dot{x}_m}{\partial x_o} & \frac{\partial \dot{x}_m}{\partial y_o} & \frac{\partial \dot{x}_m}{\partial z_o} & \frac{\partial \dot{x}_m}{\partial x_o} & \frac{\partial \dot{x}_m}{\partial y_o} & \frac{\partial \dot{x}_m}{\partial z_o} \\ \frac{\partial \dot{y}_m}{\partial x_o} & \frac{\partial \dot{y}_m}{\partial y_o} & \frac{\partial \dot{y}_m}{\partial z_o} & \frac{\partial \dot{y}_m}{\partial x_o} & \frac{\partial \dot{y}_m}{\partial y_o} & \frac{\partial \dot{y}_m}{\partial z_o} \\ \frac{\partial \dot{z}_m}{\partial x_o} & \frac{\partial \dot{z}_m}{\partial y_o} & \frac{\partial \dot{z}_m}{\partial z_o} & \frac{\partial \dot{z}_m}{\partial x_o} & \frac{\partial \dot{z}_m}{\partial y_o} & \frac{\partial \dot{z}_m}{\partial z_o} \end{bmatrix}$$

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A similar matrix is also obtained if only the critical plane midcourse corrections are considered. This G matrix is denoted as miss only.

The Impact Parameter

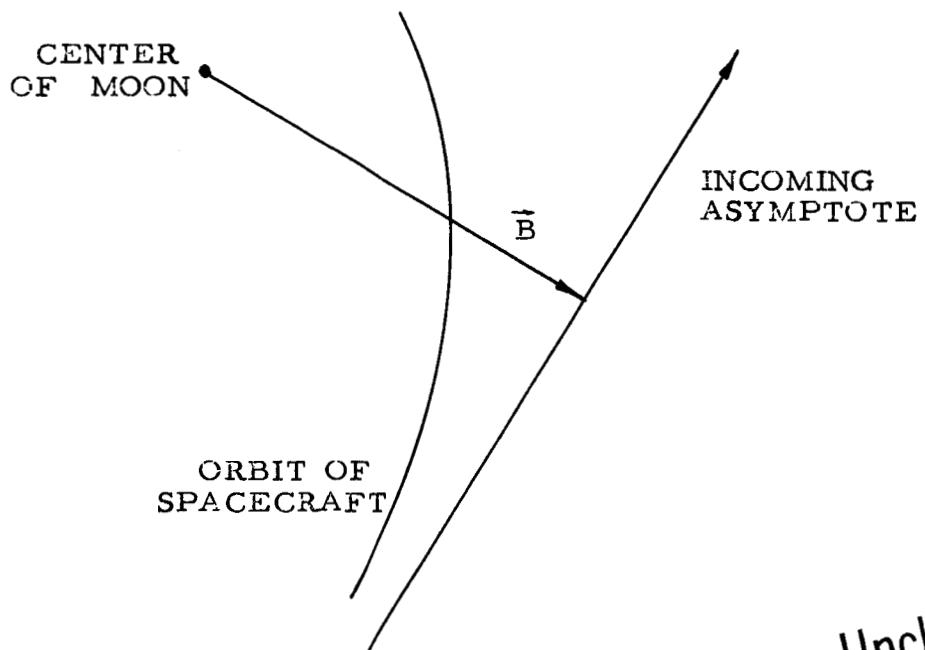
The impact parameter, B, is defined as a vector directed from the center of the moon and perpendicular to the incoming asymptote of the approach hyperbola. Thus, the impact parameter B is obtained vectorially as

$$\vec{h} = \vec{B} \times \vec{v}_\infty$$

or

$$\vec{B} = \frac{\vec{R}(\vec{v}_\infty \cdot \vec{V}) - \vec{V}(\vec{v}_\infty \cdot \vec{R})}{v_\infty^2}$$

where \vec{h} is the angular momentum vector of the hyperbola. \vec{v}_∞ is the hyperbolic excess velocity vector, \vec{R} is the radius vector and \vec{V} is the inertial velocity vector. An orbit plane diagram shows the relations.



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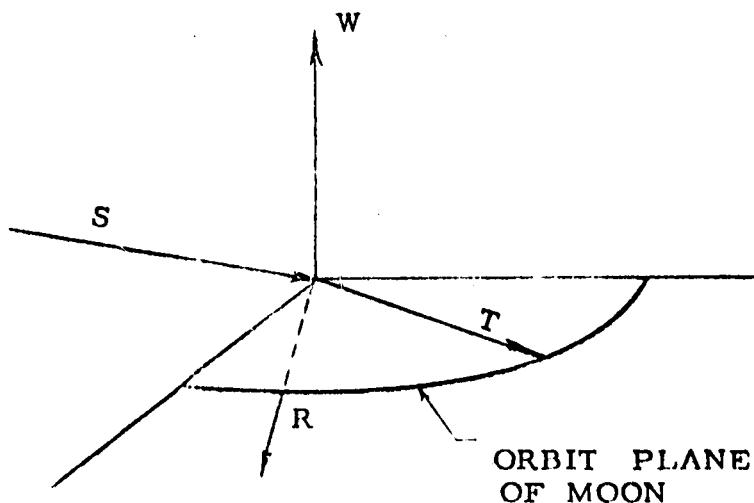
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The STR Coordinate System

The STR coordinate system for the lunar trajectories is defined as follows. T is a unit vector lying in the orbital plane of the moon and is perpendicular to the unit vector S. The components of the S vector are the direction cosines of the incoming asymptote. Clearly then, the impact parameter, B, is perpendicular to the S vector. The unit vector R completes an orthogonal system as

$$R = S \times T.$$

The following figure shows these vectors



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W is a unit vector normal to the moon's orbit plane; thus its components are the direction cosines of the moon's orbital angular momentum. The unit vector T is then defined as

$$T = \frac{\mathbf{S} \times \mathbf{W}}{|\mathbf{S} \times \mathbf{W}|}$$

In the STR system the impact parameter is resolved into two miss components which are B • T and B • R.

The Parameter of the Orbit

An STR coordinate system has also been defined for the transearth trajectories. In this system the unit vector W coincides with the earth's axis of rotation. Since the return trajectories are elliptical with respect to the earth, the "parameter of the orbit", p, is used instead of the impact parameter. The components of the S vector, in this case, are the direction cosines of perigee. The unit vector T is defined as

$$T = \mathbf{S} \times \mathbf{W}$$

and the unit vector R completes the orthogonal system. The "parameter of the orbit" is defined as a vector directed from the central body and perpendicular to the direction of perifocus. The direction cosines of the "p" vector are

$$\vec{p} = \frac{(\vec{r} \times \vec{v}) \times \vec{q}}{(\vec{r} \times \vec{v}) \times \vec{q}}$$

and its magnitude is given as

$$p = \frac{q}{1+e}$$

where q is the distance of closest approach and e is the eccentricity of the conic section. The "parameter of the orbit" is resolved into two miss components which are P • T and P • R.

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TABLE I

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***** MIDCOURSE SUMMARY *****
MISS COMPONENTS

DDCA -.45776367-04(KM) DINC -.19073486-05(DEG) DTF -.29802322-07(DAYS)

TIME 1 28 JANUARY 6 HR 33 MIN 4 SEC TIME-START .00000000 00

GUIDANCE ANALYSIS COEFF. -- MISS ONLY

	X0	Y0	Z0	XDOT0	YDOT0	ZDOT0
MVX	.43148768-03	.63042640-03	.23315507-03	.99999996 00	.58448221-07	.35560765-07
MVY	.69045281-03	-.11965258-02	.15683003-02	.18798161-07	.99999996 00	.11481547-08
MVZ	.23312230-03	.15683090-02	-.32927111-02	-.32584746-07	.84814429-08	.99999998 00

GUIDANCE ANALYSIS COEFF. -- MISS ONLY

	X0	Y0	Z0	XDOT0	YDOT0	ZDOT0
MVX	.15928086-03	.17182278-03	-.39274482-03	.55571068-01	.13297653 00	.18654799 00
MVY	.7237797d-03	-.11235053-02	.16564268-02	.13297654 00	.98127630 00	-.26266104-01
MVZ	.26639024-03	.16707453-02	-.31690790-02	.18654796 00	-.26266021-01	.96315177 00

MIDCOURSE SENSITIVITIES

	X	Y	Z	XDOT	YDOT	ZDOT
M1	-.39376915 03	.83298358 02	.52142544 02	-.10511270 06	-.42793834 06	-.22710341 06
M2	-.59019711 00	-.12205948 00	.52466094 00	-.17322875 03	-.59320364 03	-.45414598 03
M3	.67570106 03	-.46420804 02	-.49438790 02	.29167669 06	.67565673 06	.35747968 06

.97181732 00 -.13683289 00 -.19195794 00

	DELTA V (KM/SEC)	DELTA VC (KM/SEC)
DVX	-.20906650-07	.15489996-08
DVY	-.39721473-08	-.71339260-08
DVZ	*17362861-07	.12927315-07
MAGN	*.27465158-07	*.14846137-07

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TIME 2 28 JANUARY 10 HR 33 MIN 4 SEC TIME-START .24000000 03

GUIDANCE ANALYSIS COEFF.

	X0	Y0	Z0	XDOT	YDOT	ZDOT
MVX	- .79719108-03	.32697235-03	.19121774-03	-.20419370-01	-.96633439 00	-.51977870 00
MVY	-.28506415-02	-.25162111-03	-.28432029-04	.12658324 01	.28466307 01	.14541024 01
MVZ	.15569347-02	.51908126-06	-.38772868-03	.68877381 00	.15233111 01	.89207007 00

GUIDANCE ANALYSIS COEFF. -- MISS ONLY

	X0	Y0	Z0	XDOT	YDOT	ZDOT
MVX	-.16962818-02	* .35413894-03	* .23310927-03	-.45310344 00	-.18425595 01	-.98048057 00
MVY	* .47101867-03	-.17971932-03	* .82442244-04	* .12064773 00	* .52732615 00	* .23475302 00
MVZ	* .32930480-03	* .89001727-04	* .33052946-03	* .97981487-01	* .32690217 00	* .26302189 00

MIDCOURSE SENSITIVITIES

	X	Y	Z	XDOT	YDOT	ZDOT
M1	* .22101149 01	-.45086941 01	-.27136436 01	* .20886519 06	-.65141883 05	-.26698304 05
M2	* .39502001-02	-.15381863-01	* .12428437-01	* .25652980 03	* .55696609 03	* .12674935 04
M3	-.42713308 01	* .28165126 01	* .15542588 01	* .24293944 05	* .17411662 06	* .10275966 06
	* .31831367 00	* .84248061 00	* .43462952 00			

DELTA V (KM/SEC)

DELTA VC (KM/SEC)

DVX	-47595223-08	-23215480-09
DVY	-.12524175-07	-.54159411-09
DVZ	-.49618808-08	* 12198443-08
MAGN	.14287347-07	* 13547103-08

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TIME 3 28 JANUARY 11 HR 33 MIN 4 SEC TIME-START •30000000 03

GUIDANCE ANALYSIS COEFF.

	X0	Y0	Z0	XDOT0	YDOT0	ZDOT0
MVX	-10316355-02	.34620688-03	.20953613-03	-.11807855 00	-.12026406 01	-.64480856 00
MVY	.30245701-02	-.27513868-03	-.54310579-04	.13234756 01	.30291319 01	.15529677 01
MVZ	.16583204-02	.30961739-04	-.38826676-03	.72289658 00	.16313112 01	.94608954 00

GUIDANCE ANALYSIS COEFF. -- MISS ONLY

	X0	Y0	Z0	XDOT0	YDOT0	ZDOT0
MVX	-.18262226-32	.38051725-03	.25232233-03	-.48786030 00	-.19835593 01	-.10559341 01
MVY	.39898623-03	-.16176566-03	.87069451-04	.10159188 00	.44871287 00	.19447006 00
MVZ	.29611829-03	-.89803370-04	-.31488923-03	.88727728-01	.29205007 00	.24101682 00

MIDCOURSE SENSITIVITIES

	X	Y	Z	XDOT	YDOT	ZDOT
M1	.19469139 01	-.32414060 01	-.19545838 01	.20140514 06	-.51394612 05	-.18414190 05
M2	.33293796-02	-.10692462-01	-.82757622-02	.24348830 03	.60323916 03	.13042672 04
M3	-.31395130 01	.19152689 01	.10644558 01	-.11107004 05	.16578660 06	.98147740 05
				.25941399 00	.85719141 00	.44489019 00

DELTA V (KM/SEC)

	DELTA VC (KM/SEC)
DVX	-.39500290-08
DVY	-.12737638-07
DVZ	-.51663332-08
MAGN	.14301788-07

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GUIDANCE ANALYSIS COEFF.

X0	Y0	Z0	XDOT0	YDOT0	ZDOT0
MVX -.12380762-02	.36588613-03	.22704913-03	-.20079008 00	-.14124333 01	-.75590716 00
MVY .31800996-02	-.29603549-03	-.75427216-04	.13761395 01	.31918807 01	.16405263 01
MVZ .17497354-02	.14176284-04	-.39129610-03	.75390565 00	.17271431 01	.99484979 00

GUIDANCE ANALYSIS COEFF. -- MISS ONLY

X0	Y0	Z0	XDOT0	YDOT0	ZDOT0
MVX -.19340703-02	.40246359-03	.26817290-03	-.51670428 00	-.21005960 01	-.11185344 01
MVY .33433159-03	-.14647825-03	.92718928-04	.84435252-01	.37813344 00	.15792286 00
MVZ .26599819-03	.92153003-04	-.30362744-03	.80432028-01	.26010158 00	.22179229 00

MIDCOURSE SENSITIVITIES

X	Y	Z	XDOT	YDOT	ZDOT
M1 .17446102 01	-.24616715 01	-.14821797 01	.19477877 06	-.41230542 05	-.12288105 05
M2 .28738287-02	-.76317186-02	.53884675-02	.23235444 03	.63567125 03	.13285772 04
M3 -.23936284 01	.14429120 01	.80815656 00	-.12328402 04	.15982528 06	.94822562 05
			.21193857 00	.86657055 00	.45181581 00

DELTA V (KM/SEC)

DVX	DVY	DVZ	MAGN
-.33164699-08	-.12963122-07	-.53486723-08	.14410059-07

DELTA VC (KM/SEC)

DVX	DVY	DVZ	MAGN
-.27452374-09	-.52526750-09	.1362228-08	.12815114-08

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GUIDANCE ANALYSIS COEFF.

	X0	Y0	Z0	XDOT	YDOT	ZDOT
MVX	- .19121812-02	.44340807-03	.23090883-03	-.45500540 00	-.21057640 01	-.11235319 01
MVY	.37196267-02	-.36609663-03	-.13704325-03	.15668402 01	.37530014 01	.19401014 01
MVZ	.20633952-02	-.32722268-04	-.41469372-03	.86530230 00	.20543256 01	.11553573 01

GUIDANCE ANALYSIS COEFF. -- MISS ONLY

	X0	Y0	Z0	XDOT	YDOT	ZDOT
MVX	-.22596964-02	.46900036-03	.31553432-03	-.50377587 00	-.245+0202 01	-.13074175 01
MVY	.12906935-03	-.10166831-03	.11733945-03	.24730728-01	.15475364 00	.40173394-01
MVZ	.16998305-03	.10671882-03	-.28052347-03	.54436863-01	.15687649 00	.16376934 00

MIDCOURSE SENSITIVITIES

	X	Y	Z	XDOT	YDOT	ZDOT
M1	* 12953661 01	-.10323317 01	-.63136592 00	.17337733 06	-.17655384 05	.17349798 04
M2	* 19132203-02	-.17024321-02	-.69445444-03	.19894797 03	.69552208 03	.13554626 04
M3	-.97562151 00	.33910400 00	.48344519 00	.21134430 05	.14468959 06	.86228100 05

* 35299705-01 * 88132336 00 * 46474944 00

	DELTA V (KM/SEC)	DELTA VC (KM/SEC)
DVX	-.16306845-08	-.32384840-09
DVY	-.13979145-07	-.53879279-09
DVZ	-.600052336-08	.10822754-05
MAGN	.15301585-07	.12531631-03

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GUIDANCE ANALYSIS COEFF.

X0	Y0	Z0	XDOT0	YDOT0	ZDOT0
MVX -.22011354-02	.48132950-03	.32063615-03	-.55836405 00	-.24058874 01	-.12828260 01
MVY .39713827-02	-.39737862-03	-.16128151-03	.16593775 01	.40132468 01	.20779685 01
MVZ .22088612-02	-.50161767-04	-.43010821-03	.91838349 00	.22046212 01	.12457036 01

GUIDANCE ANALYSIS COEFF. — MISS ONLY

X0	Y0	Z0	XDOT0	YDOT0	ZDOT0
MVX -.23949137-02	.49674010-03	.33500371-03	-.63992570 00	-.26008021 01	-.13858016 01
MVY .48123939-04	-.85373669-04	.12960574-03	.80705839-02	.66980957-01	-.68872690-02
MVZ .13258316-03	.11495837-03	-.27616404-03	.44474168-01	.11616721 00	.14235032 00

MIDCOURSE SENSITIVITIES

X	Y	Z	XDOT	YDOT	ZDOT
M1 .11764485 01	-.78157687 00	-.44199264 00	.16450394 06	-.11063048 05	.55512335 04
M2 .16642868-02	-.27572182-03	-.22747717-02	.18612169 03	.70231443 03	-.13444383 04
M3 -.65084542 00	.76609051 00	.44551383 00	.26909192 05	.13894664 06	.82903153 05

.43614086-01 .88301593 00 .46731217 00

DELTA V (KM/SEC)

DVX	DVY	DVZ	MAGN	DELTA VC (KM/SEC)
-.10434686-08	-.14553756-07	-.63284245-08	.15904389-07	.335200843-09
-.55437033-09				-.10803693-08
				.12642920-08

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GUIDANCE ANALYSIS COEFF.

	X0	Y0	Z0	XDOT0	YDOT0	ZDOT0
MVX	-.24749143-02	.51922690-03	.34978654-03	-.65394310 00	-.26914762 01	-.14344713 01
MVY	.42233472-02	-.42791798-03	-.18359101-03	.17536766 01	.42729381 01	.22151107 01
MVZ	.23539690-02	-.65675623-04	-.44730568-03	.97252908 00	.23538851 01	.13258541 01

GUIDANCE ANALYSIS COEFF. -- MISS ONLY

	X0	Y0	Z0	XDOT0	YDOT0	ZDOT0
MVX	-.25246229-02	.52339718-03	.35359339-03	-.67459992 00	-.27416141 01	-.14609706 01
MVY	-.23528979-04	-.71628746-04	.14164852-03	-.11146170-01	-.10613867-01	-.48863392-01
MVZ	.10001083-33	.12341890-03	-.27469026-03	.35879034-01	.80451863-01	.12428785 00

MIDCOURSE SENSITIVITIES

	X	Y	Z	XDOT	YDOT	ZDOT
M1	•10911575 01	-.57989053 00	-.31387309 00	.15635592 06	-.62059786 04	•82449546 04
M2	•14872771-02	.72159033-03	-.34118063-02	.17480817 03	.70051534 03	-.13237563 04
M3	-.43130005 00	.73450576 00	.42997187 00	.30758067 05	.13356050 06	.79759866 05
			•10338312-01	.88325753 00	•46877412 03	

DELTA V (KM/SEC)

	DELTA V (KM/SEC)
DVX	-.54382613-09
DVY	-.15175584-07
DVZ	-.66616837-08
MAGN	.16582283-07

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GUIDANCE ANALYSIS COEFF.

	X0	Y0	Z0	XDOT0	YDOT0	ZDOT0
MVX	• 27406913-02	• 55755671-03	• 37885356-03	- .74488901 00	- .29696784 01	- • 15822450 01
MVY	• 44810144-02	- • 45848817-03	- .20488247-03	• 18514837 01	.45378736 01	.23546900 01
MVZ	• 25019147-02	- .80014342-04	- .46620552-03	.10284684 01	.25055367 01	.14077858 01

GUIDANCE ANALYSIS COEFF. -- MISS ONLY

	X0	Y0	Z0	XDOT0	YDOT0	ZDOT0
MVX	• 26537425-02	• 54997014-03	• 37203154-03	- .70911416 00	- .28817933 01	- • 15357808 01
MVY	- .88348083-04	- • 59796147-04	• 15363030-03	- .28568333-01	- .80690706-01	- .87113142-01
MVZ	• 71152448-04	• 13207771-03	- .27548760-03	.28337794-01	.48600643-01	.10882069 00

MIDCOURSE SENSITIVITIES

	X	Y	Z	XDOT	YDOT	ZDOT
M1	• 10272109 01	- • 43685163 00	- .22228433 00	• 14874059 06	- .25732504 04	.10157690 05
M2	• 13554570-02	• 14533391-02	- .42644586-02	.16459716 03	.69255691 03	- .12959853 04
M3	- .27502042 00	.72238135 00	• 42474146 00	.33270258 05	.12832340 06	.76687486 05
			- .16797118-01	.88272779 00	.46958440 00	

	DELTA V (KM/SEC)	DELTA VC (KM/SEC)
DVX	- 10316576-09	- .39343868-03
DVY	- 15849270-07	- .59475025-03
DVZ	- .70110008-08	.1039410-08
MAGN	.17331017-07	.13142327-03

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GUIDANCE ANALYSIS COEFF.

X0	Y0	Z0	XDOT0	YDOT0	ZDOT0
MVX -.30038526-02	.59677163-03	.40826486-03	-.83343177 00	-.32459297 01	-.17290239 01
MVY .474388801-02	-.49969399-03	-.22578920-03	.19543091 01	.48127624 01	.24992484 01
MVZ .26553685-02	-.93685901-04	-.48687503-03	.10871089 01	.26623949 01	.14923262 01

GUIDANCE ANALYSIS COEFF. -- MISS ONLY

X0	Y0	Z0	XDOT0	YDOT0	ZDOT0
MVX -.27857285-02	.57716164-03	.34082731-03	-.74439281 00	-.30250902 01	-.16122386 01
MVY -.14816404-03	-.49435050-04	.16569667-03	-.44681195-01	-.14524959 00	-.12265770 00
MVZ .45181284-04	.14097777-03	-.27820803-03	.21621379-01	.19710823-01	.95411238-01

MIDCOURSE SENSITIVITIES

X	Y	Z	XDOT	YDOT	ZDOT
M1 .97793469 00	-.33112759 00	-.15416612 00	.14152361 06	.17343852 03	.11501616 05
M2 .12543071-02	.20994631-02	-.49240702-02	.15521584 03	.68000630 03	.12628086 04
M3 -.15963641 00	.71973789 00	.42452052 00	.34814991 05	.12313629 06	.73632207 05

-.39276636-01 .88178941 00 .47000508 00

DELTA V (KM/SEC)

DVX .29677591-09	-41421107-09
DVY -.16580957-07	-.51877592-09
DVZ -.73817607-08	.11262386-08
MAGN .18152317-07	.13501765-08

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**** MIDCOURSE SUMMARY ****

MISS COMPONENTS

OP.T .12207031-03(KM) DP.R -.0000000 00(KM) DIF .0000000 00(DAYS)

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GUIDANCE ANALYSIS COEFF.

	XO	YO	ZO	XOCFO	YOCFO	ZOCFO
MVX	-.34799190-03	-.20171941-03	-.48932197-04	.99999997 00	.18898196-07	.42671524-08
MVY	-.20171370-03	.31881073-03	.57963454-03	-.10114318-08	.99999996 00	.41650875-08
MVZ	-.48956987-04	.57968700-03	.55093112-03	.15992879-07	.39438092-09	.99999998 00

GUIDANCE ANALYSIS COEFF. -- MISS ONLY

	XO	YO	ZO	XOCFO	YOCFO	ZOCFO
MVX	-.12691052-03	.19686734-03	.23007989-04	-.16641307 00	.28342106 00	.24164489 00
MVY	-.27688177-03	.18329052-03	.55517475-03	.28342106 00	.90363630 00	.82159703-01
MVZ	-.11304531-03	.46414240-03	.57178554-03	.24164491 00	-.82159696-01	.92995058 00

MIDCOURSE SENSITIVITIES

	X	Y	Z	XOCF	YOCF	ZOCF
M1	.55057378 02	-.60672823 02	-.60709318 02	-.64194053 05	-.15161544 06	-.43619021 05
M2	-.92617845 01	.30828566 02	-.32082436 02	.17469413 05	.16097138 04	.58375108 05
M3	-.69105226 02	.38595393 01	.49959481 02	.14092964 06	.99182625 05	.11511388 04
				-.91300983 00	.31042499 00	.26466845 00

DELTA V (KM/SEC)

CVX	.75292477-09	DELTA VC (KM/SEC)
DVY	-.10675653-08	-.22460804-09
DVZ	-.19588279-09	-.73520242-09
MAGN	.13209699-08	-.87489551-10
		-.77370915-09

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GUIDANCE ANALYSIS COEFF.

	X0	Y0	Z0	XDOT	YDOT	ZDOT
MVX	- .54257733-03	.26376056-03	.12839635-03	.10788738 01	.72363084 00	.43245591 00
MVY	- .44266929-03	.74225129-03	.5500C7506-03	.31829008 00	.15092402 01	.56115553 00
MVZ	- .24149926-03	.64193684-03	.12392481-03	.22052817 00	.61094341 00	.84812377 00

GUIDANCE ANALYSIS COEFF. — MISS ONLY

	X0	Y0	Z0	XDOT	YDOT	ZDOT
MVX	- .36710993-03	.50043710-03	.20814107-03	.45904702 00	.89983415 00	.52814536 00
MVY	- .53134240-03	.62264590-03	.50977575-03	.63152188 00	.14201952 01	.51279855 00
MVZ	- .29930077-03	.56397214-03	-.15019387-03	.42470812 00	.55289948 00	.81660227 00

MIDCOURSE SENSITIVITIES

	X	Y	Z	XDOT	YDOT	ZDOT
M1	-.47355270 00	-.12048712 00	-.11163950 00	-.378C1569 05	-.94674058 05	.30485372 05
M2	.11007405 00	.79811681-01	.51239799-01	.95322482 04	-.40152433 05	.90534653 05
M3	.13209566 01	.12215284 00	.62496131-01	.13887827 06	.37212150 05	-.94077539 05
				-.85626720 00	.43271788 00	.28206688 00

	DELTA V (KM/SEC)	DELTA VC (KM/SEC)
DVX	-.44923070-10	-.71845848-09
DVY	-.14814848-08	-.11411111-08
DVZ	-.65231376-09	-.43044139-09
MAGN	.16193605-08	.14154847-08

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TIME 3 31 JANUARY 23 HR 16 MIN 39 SEC TIME-START .30000000 03

GUIDANCE ANALYSIS COEFF.

X0	Y0	Z0	XDOT0	YDOT0	ZDOT0
MVX -.56257952-03	.27614494-03	.13438981-03	.11162839 01	.75395620 00	.45015975 00
MVY -.4471820-03	.74939185-03	.55293112-03	.32443611 00	.15218405 01	.56868242 00
MVZ -.24529293-03	.64849167-03	-.12224230-03	.22458268 00	.62101316 00	.85530412 00

GUIDANCE ANALYSIS COEFF. — MISS ONLY

X0	Y0	Z0	XDOT0	YDOT0	ZDOT0
MVX -.36609099-03	.49933160-03	.20698193-03	.45786460 00	.89700812 00	.52738108 00
MVY -.54411028-03	.63990234-03	.51731933-03	.64743925 00	.14516630 01	.53079966 00
MVZ -.30846064-03	.57674097-03	-.14557942-03	.43625325 00	.57502442 00	.83047879 00

MIDCOURSE SENSITIVITIES

X	Y	Z	XDOT	YDOT	ZDOT
M1 -.36181581 00	-.15527804 00	-.33812904-01	-.36319269 05	-.94173749 05	.30732238 05
M2 .67724717-01	.19626473-01	.12400996 00	.92198120 04	-.40320395 05	.90206767 05
M3 .11694492 01	.52698902-01	-.11718475 00	.13442108 06	.36913393 05	-.93945323 05

-.86257753 00 .42315780 00 .27730395 00

DELTA V (KM/SEC)

DVX	DVY	DVZ	MAGN	DELTA VC (KM/SEC)
-.52598227-10	-.14917833-08	-.66141765-09	.16326841-08	-.71618206-09
				-.11662466-08
				-.44808677-09
				.14400797-08

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TIME 4 1 FEBRUARY HR 16 MIN 39 SEC TIME-START • 36000000 03

GUIDANCE ANALYSIS COEFF.

	X0	Y0	Z0	XDOT0	YDOT0	ZDOT0
MVX	-• 58009051-03	.28515902-03	.13915904-03	.111504717 01	.77838690 00	.46417016 00
MVY	-• 45220518-03	.75687000-03	.55661616-03	.32859963 00	.15352030 01	.57568259 00
MVZ	-• 24824769-03	.65541602-03	-.12147322-03	.22679854 00	.62994463 00	.86310814 00

GUIDANCE ANALYSIS COEFF. -- MISS ONLY

	X0	Y0	Z0	XDOT0	YDOT0	ZDOT0
MVX	-• 36599800-03	.49949505-03	.20633399-03	.45784220 00	.89644390 00	.52796555 00
MVY	-• 55486936-03	.65408903-03	.52440363-03	.66073755 00	.14785909 01	.54509064 00
MVZ	-• 31595436-03	.53763232-03	-.14271727-03	.44584234 00	.59260913 00	.84293286 00

MIDCOURSE SENSITIVITIES

	X	Y	Z	XDOT	YDOT	ZDOT
M1	-.29966608 00	-.17948864 00	.95531026-02	-.35138458 05	-.93568711 05	.30769124 05
M2	-.43344452-01	-.14884728-01	.16735772 00	.90235519 04	-.40323792 05	.89676305 05
M3	.10787229 01	.19201561-01	-.21818169 00	.13038685 06	.36790827 05	-.93325945 05
			-.86712149 00	.41581242 00	.27422684 00	

DELTA V (KM/SEC)

	DELTA VC (KM/SEC)
DVX	-.55683163-10
DVY	-.15042851-08
DVZ	-.67081287-09
MAGN	.16480182-08

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TIME 5 1 FEBRUARY 2 HR 16 MIN 39 SEC TIME-START .48000000 03

GUIDANCE ANALYSIS CGEFF.

	X0	Y0	Z0	XDDOT	YDDOT	ZDDOT
MVX	-.611178728-03	.29798850-03	.14694435-03	.12150658 01	.81863323 00	.48664505 00
MVY	-.46052172-03	.77287064-03	.56557651-03	.33388051 00	.15640238 01	.58927186 00
MVZ	-.25284628-03	.67026192-03	-.12139894-03	.22809727 00	.64636857 00	.88013759 00

GUIDANCE ANALYSIS CGEFF. — MISS ONLY

	X0	Y0	Z0	XDDOT	YDDOT	ZDDOT
MVX	-.36773221-03	.50247547-03	.20605309-03	.46021010 00	.89998049 00	.53198593 00
MVY	-.57361809-03	.67811030-03	.53818520-03	.68368456 00	.15263270 01	.56826064 00
MVZ	-.32855077-03	.60683119-03	-.13973414-03	.46224923 00	.62113507 00	.86607308 00

MIDCUURSE SENSITIVITIES

	X	Y	Z	XDDOT	YDDOT	ZDDOT
M1	-.23706048 00	-.21064852 00	.54140331-01	-.33238227 05	-.92154256 05	.30518080 05
M2	.17857617-01	-.51714837-01	.21580635 00	.88155229 04	-.40067314 05	.88276672 05
M3	.97725981 00	-.64232338-02	-.32146830 00	.12302784 06	.36765400 05	-.91331822 05
				-.87338246 00	.40472998 00	.27091831 00

DELTA V (KM/SEC)

	DELTA VC (KM/SEC)
DVX	-.54416691-10
DVY	-.15337389-08
DVZ	-.69070443-09
MAGN	.16829702-08

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TIME 6 1 FEBRUARY 4 HR 16 MIN 39 SEC TIME-START .60000000 03

GUIDANCE ANALYSIS CCEFF.

	X0	Y0	Z0	XGOT	YGOT	ZGOT
MVX	-.64218498-03	.30734678-03	.15376007-03	.12792708 01	.85393722 00	.50571461 00
MVY	-.46863565-03	.79024820-03	.57602177-03	.33704816 00	.15954334 01	.60307727 00
MVZ	-.25651711-03	.68637912-03	-.12241533-03	.22693177 00	.66222545 00	.89877968 00

GUIDANCE ANALYSIS COEFF. -- MISS ONLY

	X0	Y0	Z0	XGOT	YGOT	ZGOT
MVX	-.37118809-03	.50786181-03	.20662733-03	.46474991 00	.90766874 00	.53862921 00
MVY	-.59096276-03	.69973636-03	.55215765-03	.70472022 00	.15711791 01	.58821972 00
MVZ	-.33980124-03	.62475584-03	-.13866376-03	.47715442 00	.64571243 00	.68866421 00

MIDCURSE SENSITIVITIES

	X	Y	Z	XGOT	YGOT	ZGOT
M1	-.20831769 00	-.23044321 00	.75919031-01	-.31646751 05	-.90562300 05	.3C041944 05
M2	-.56332231-02	-.70751693-01	.24252244 00	.87357511 04	-.39620159 05	.86618923 05
M3	.92156610 00	-.11061737-01	-.37027822 00	.11620846 06	.36835330 05	-.88822356 05
				-.87766325 00	.39617433 00	.26972787 00

DELTA V (KM/SEC)

DVX	-.47499895-10				-.72458216-09
DVY	-.15675900-08				-.12619572-08
DVZ	-.71223718-09				-.50415285-09
MAGN	.17224623-08				.15400407-08

DELTA VC (KM/SEC)

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TIME 7 1 FEBRUARY 6 HR 16 MIN 39 SEC TIME-START .72000000 03

GUIDANCE ANALYSIS COEFF.

XO	Y0	Z0	XDCT0	YDCT0	ZDCT0
MVX -.67311889-03	.31504264-03	.16035177-03	.13459810 01	.88788041 00	.52353655 00
MVY -.47689406-03	.809028883-03	.58764855-03	.33907190 00	.16293805 01	.61750945 00
MVZ -.25966973-03	.70380047-03	-.12409799-03	.22376768 00	.67824362 00	.91895695 00

GUIDANCE ANALYSIS COEFF. — MISS ONLY

XO	Y0	Z0	XDCT0	YDCT0	ZDCT0
MVX -.37584375-03	.51495080-03	.20774418-03	.47081168 00	.91822006 00	.54716466 00
MVY -.60812837-03	.72077788-03	.56672682-03	.72542185 00	.16159869 01	.60707863 00
MVZ -.35069407-03	.64258945-03	-.13860934-03	.49174066 00	.66895374 00	-.91172211 00

MIDCOURSE SENSITIVITIES

X	Y	Z	XDCT	YDCT	ZDCT
M1 -.19329170 00	-.24503956 00	.88612015-01	-.30206397 05	-.88848115 05	.29446084 05
M2 -.99978216-03	-.82571279-01	.26025688 00	.87213018 04	-.39065423 05	-.84805338 05
M3 .88491668 30	-.78621289-02	-.39701178 00	.10971271 06	.36906481 05	-.86051449 05

-.88091526 00 .38888656 00 .26973238 00

DELTA V (KM/SEC)	DELTA VC (KM/SEC)
DVX -.36999723-10	-.73295428-09
DVY -.16051340-08	-.12978997-08
DVZ -.73559703-09	-.52249880-09
MAGN .17660485-08	.15794843-08

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TIME 8 1 FEBRUARY 8 HR 16 MIN 39 SEC TIME-START • 84000000 03

GUIDANCE ANALYSIS COEFF.

X0	Y0	Z0	XDCO	YDCO	ZDCO
MVX - .70560585-03	.32188334-03	.16709226-03	.14169480 01	.92223197 00	.54113999 00
MVY -.48546797-03	.8229374-03	.60036408-03	.34035704 00	.16659580 01	.63279844 00
MVZ -.26246300-03	.72261846-03	-.12627573-03	.21914810 00	.69477953 00	.94071750 00

GUIDANCE ANALYSIS COEFF. — MISS ONLY

X0	Y0	Z0	XDCO	YDCO	ZDCO
MVX -.38145100-03	.52341230-03	.20924605-03	.47808771 00	.93101654 00	.55725554 00
MVY -.62571342-03	.74210233-03	.58212627-03	.74655455 00	.16621574 01	.62582606 00
MVZ -.36170369-03	.66091993-03	-.13918121-03	.50658216 00	.69209009 00	.93578368 00

MIDCURSE SENSITIVITIES

X	Y	Z	XDOT	YDOT	ZDOT
M1 -.18487143 00	-.25704521 00	.97028656-01	-.28847751 05	-.87039465 05	.28776003 05
M2 -.48537907-02	-.90968498-01	.27371711 00	.87435760 04	-.38439213 05	.82881294 05
M3 .85746105 00	-.10828079-02	-.41320521 00	.10344394 06	.36940022 05	-.83130273 05
			-.88356782 00	.38227523 00	.27050617 00

DELTA V (KM/SEC)

DVX	- .23687623-10	DELTA VC (KM/SEC)
DVY	-.16462102-08	-.74311370-09
DVZ	-.76099091-09	-.13349508-08
MAGN	.18137464-08	-.54073708-09
		.16207122-08

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TIME 9 1 FEBRUARY 10 HR 16 MIN 39 SEC TIME-START .96000000 03

GUIDANCE ANALYSIS COEFF.

	X0	Y0	Z0	XCCOT0	YCCOT0	ZCOT0
MVX	-.74036747-03	.32828228-03	.17421566-03	.14935351 01	.95807395 00	.55911733 00
MVY	-.49446967-03	.85116924-03	.61417092-03	.34109099 00	.17053560 01	.64912289 00
MVZ	-.26495681-03	.74297434-03	-.12888111-03	.21269198 00	.71206795 00	.96418245 00

GUIDANCE ANALYSIS COEFF. — MISS ONLY

	X0	Y0	Z0	XCCOT0	YCCOT0	ZCOT0
MVX	-.38789858-03	.53310441-03	.21104987-03	.48644206 00	.94577423 00	.56876597 00
MVY	-.64408620-03	.76422600-03	.59853547-03	.76858341 00	.17105769 01	.64502720 00
MVZ	-.37311663-03	.68012189-03	-.14018418-03	.52203204 00	.71584226 00	.96122163 00

MIDCURSE SENSITIVITIES

	X	Y	Z	XCOT	YCOT	ZDOT
M1	-.18002827 00	-.26771770 00	.10320669 00	-.27535708 05	-.85149768 05	.28054166 05
M2	-.71511140-02	-.97587242-01	.28498636 00	-.87874896 04	-.37759623 05	.80869036 05
M3	.83487872 06	.75940199-02	-.42379206 00	.97353683 05	.36917562 05	-.80114535 05
				-.88584080 00	.37602309 00	.27183219 00

DELTA V (KM/SEC)

	DELTA VC (KM/SEC)	
DVX	-.78084102-11	-.75483301-09
DVY	-.16909151-08	-.13738169-08
DVZ	-.78867890-09	-.55944432-09
MAGN	.18658160-08	.16643689-08

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TIME 10 1 FEBRUARY 12 HR 16 MIN 39 SEC TIME-START .10800000 04

GUIDANCE ANALYSIS COEFF.

	X0	Y0	Z0	XDDCT	YDDCT	ZDDCT
MVX	-.77803844-03	.33448515-03	.18191000-03	.15770276 01	.99623441 00	.57788439 00
MVY	-.50399121-03	.87481941-03	.62912424-03	.34136191 00	.17478375 01	.66665175 00
MVZ	-.26715519-03	.76504404-03	-.13189731-03	.20518479 00	.73028817 00	.98951799 00

GUIDANCE ANALYSIS COEFF. — MISS ONLY

	X0	Y0	Z0	XDDCT	YDDCT	ZDDCT
MVX	-.39514948-03	.54398837-03	.21311063-03	.49583219 00	.96238877 00	.58167161 00
MVY	-.66352758-03	.78752674-03	.61612402-03	.79185804 00	.17619398 01	.66507367 00
MVZ	-.38514179-03	.70048592-03	-.14151174-03	.53835341 00	.74071559 00	.98835090 00

MIDCOURSE SENSITIVITIES

	X	Y	Z	XDDCT	YDDCT	ZDDCT
M1	-.17728917 00	-.27773394 00	.10813592 00	-.26250411 05	-.83185888 05	.27292781 05
M2	-.84955172-02	-.10323920 00	.29511098 00	.88442854 04	.37036252 05	.78780190 05
M3	.81502718 00	.17430487-01	-.43116067 00	.91415285 05	.36827994 05	-.77035251 05
				-.88785823 00	.36993935 00	.27359211 00

DELTA V (KM/SEC)

	CVX	CVY	CVZ	MAGN
	.10640244-10	-.17394966-08	-.81896906-09	.19226731-08

	CVX	CVY	CVZ	MAGN
	-.76802803-09	-.14150528-08	-.57902367-09	.17109968-08

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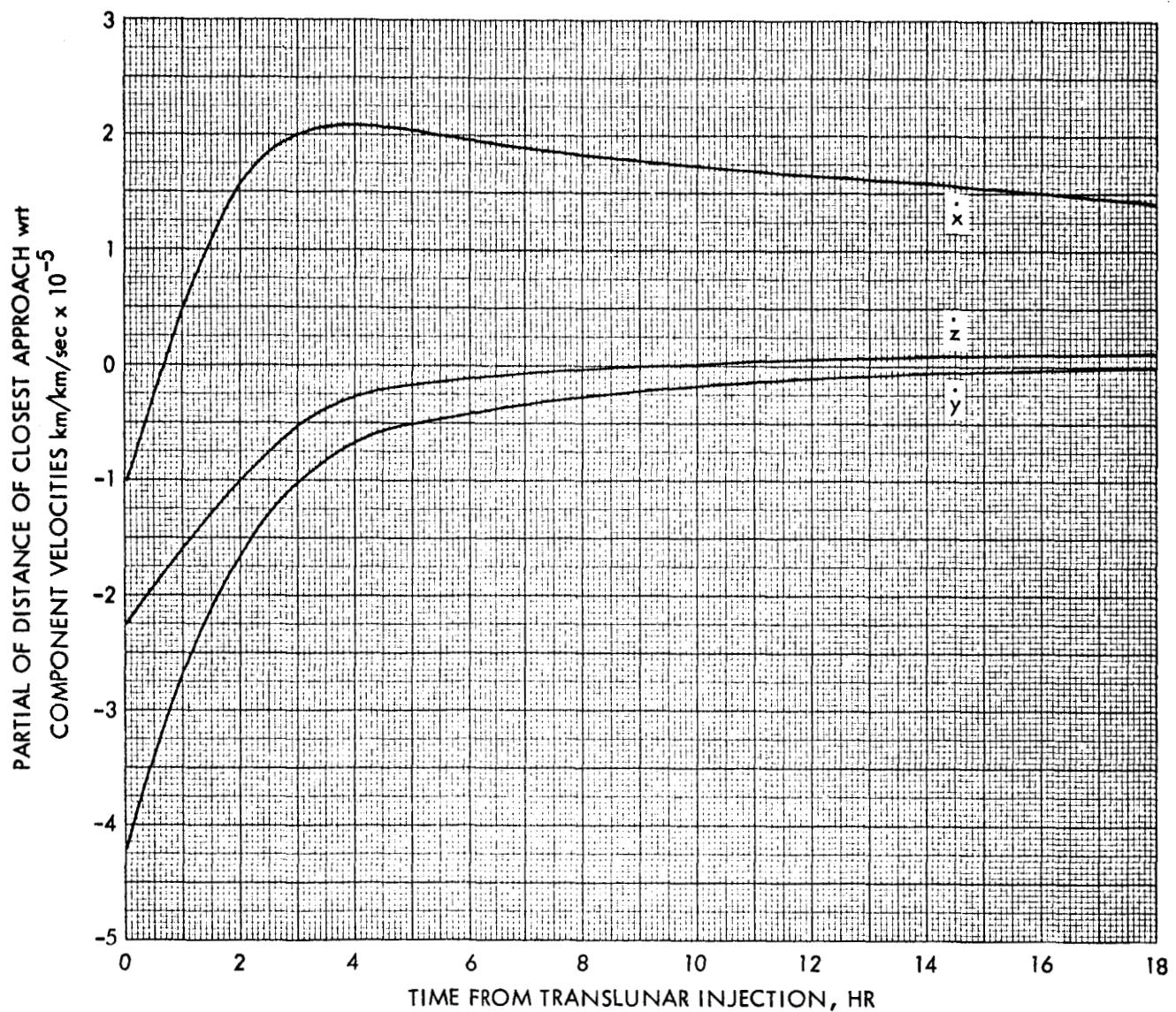


Figure 3.1-1. Translunar Flight - Closest Approach
Midcourse Sensitivities

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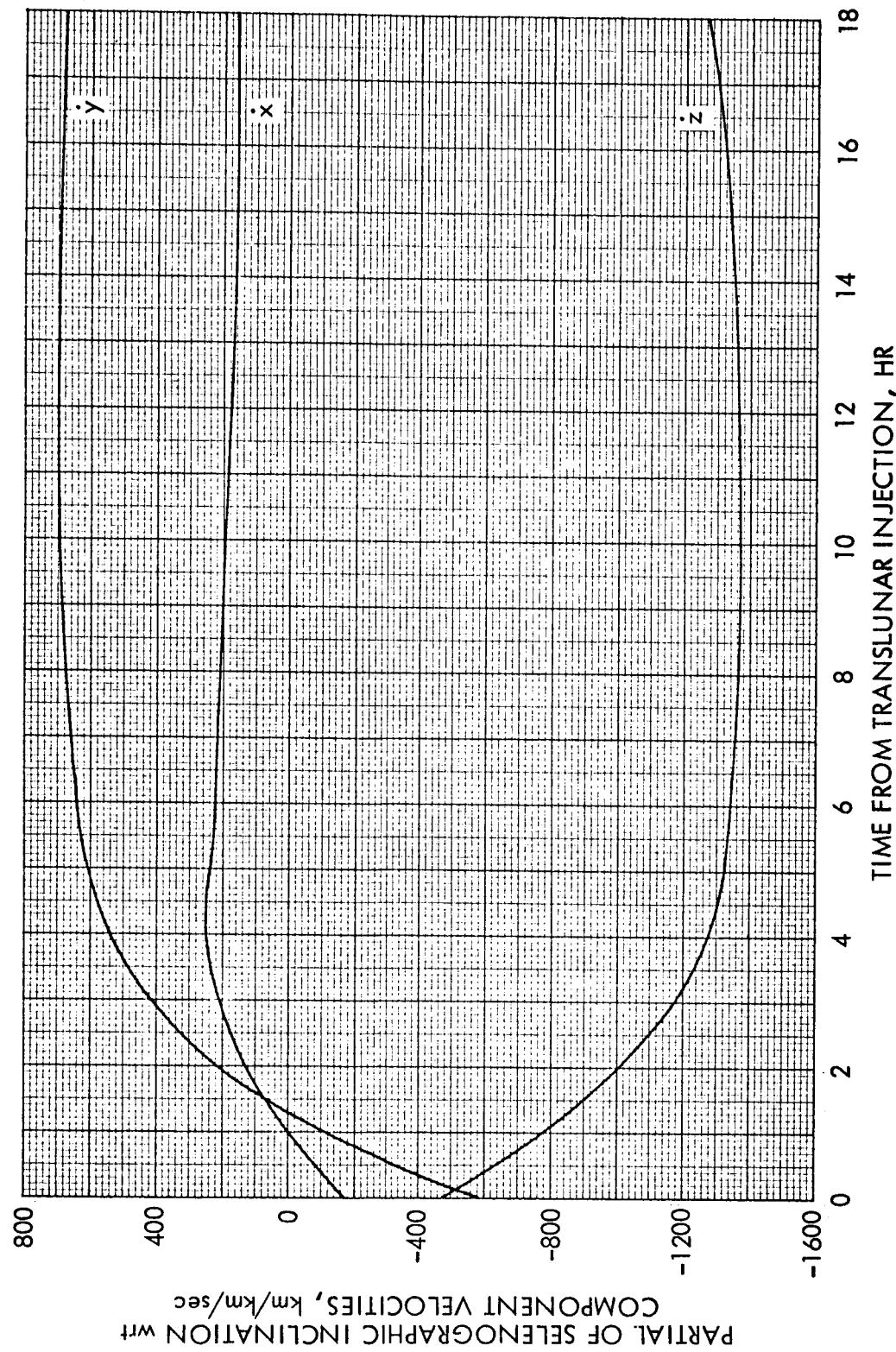


Figure 3.1-2. Translunar Flight - Inclination Midcourse Sensitivities

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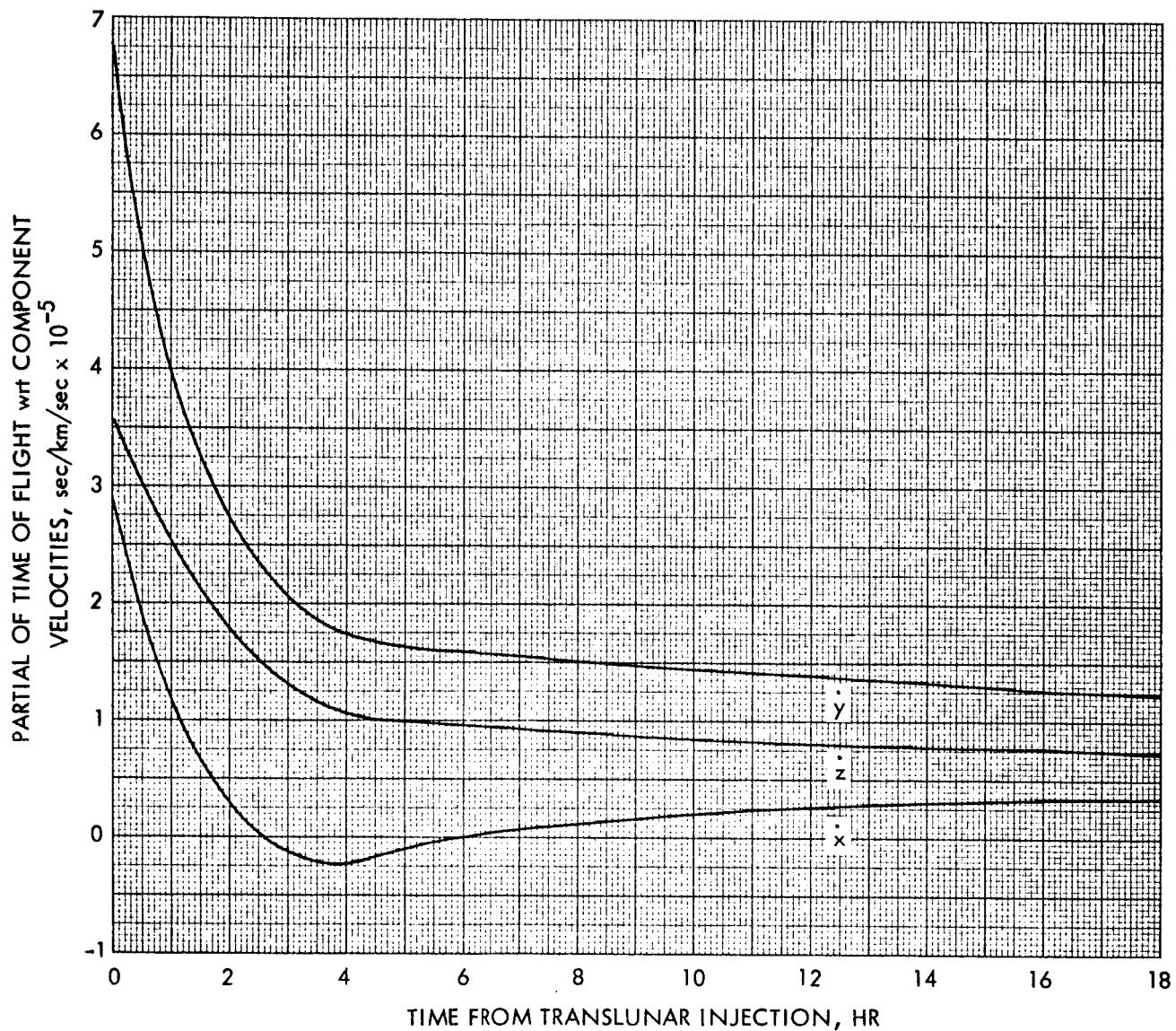


Figure 3.1-3. Translunar Flight - Time of Flight
Midcourse Sensitivities

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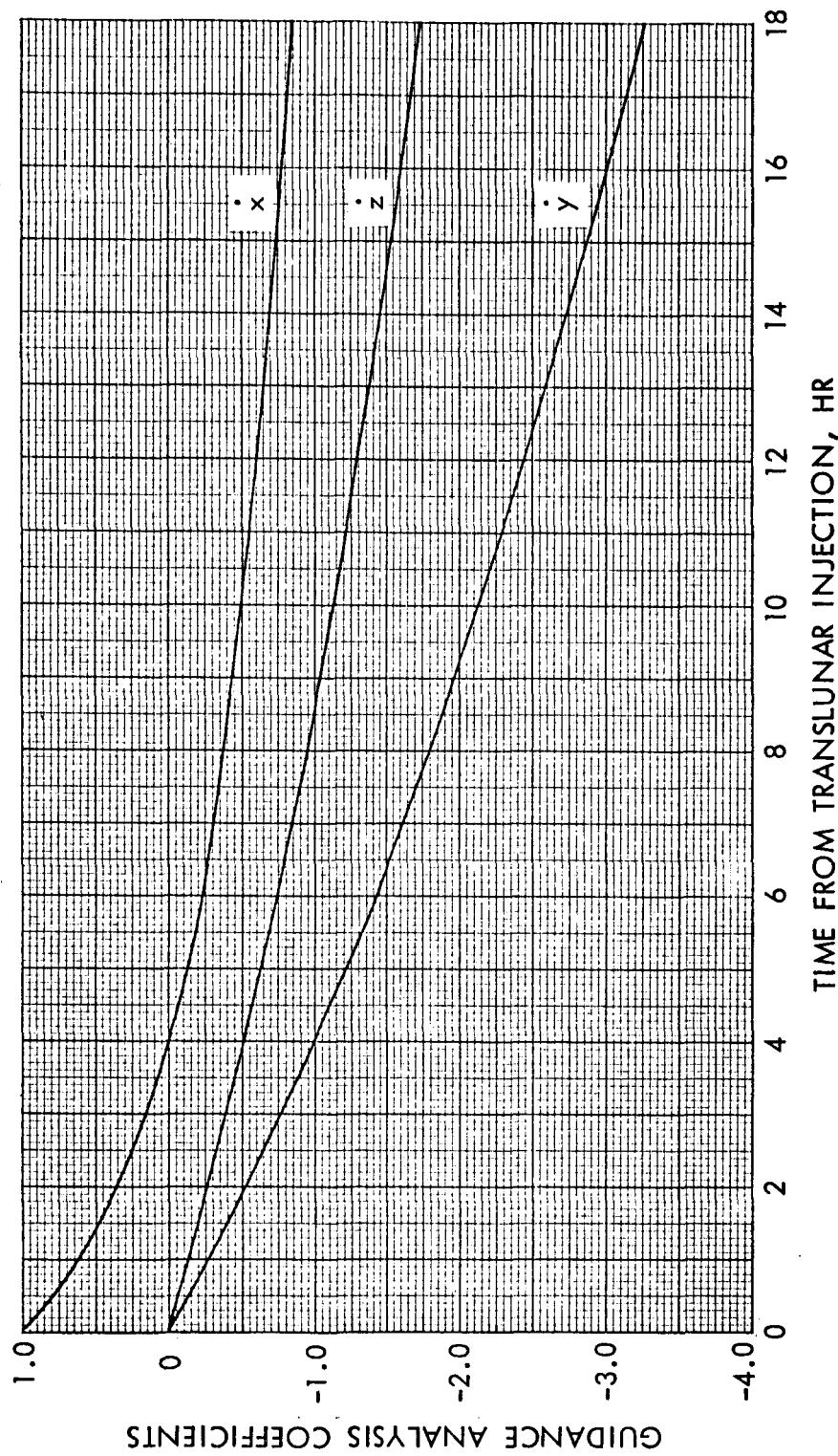


Figure 3.1-4. Translunar Flight - Partials of the X Component of Midcourse Velocity with Respect to the Injection Velocity Components

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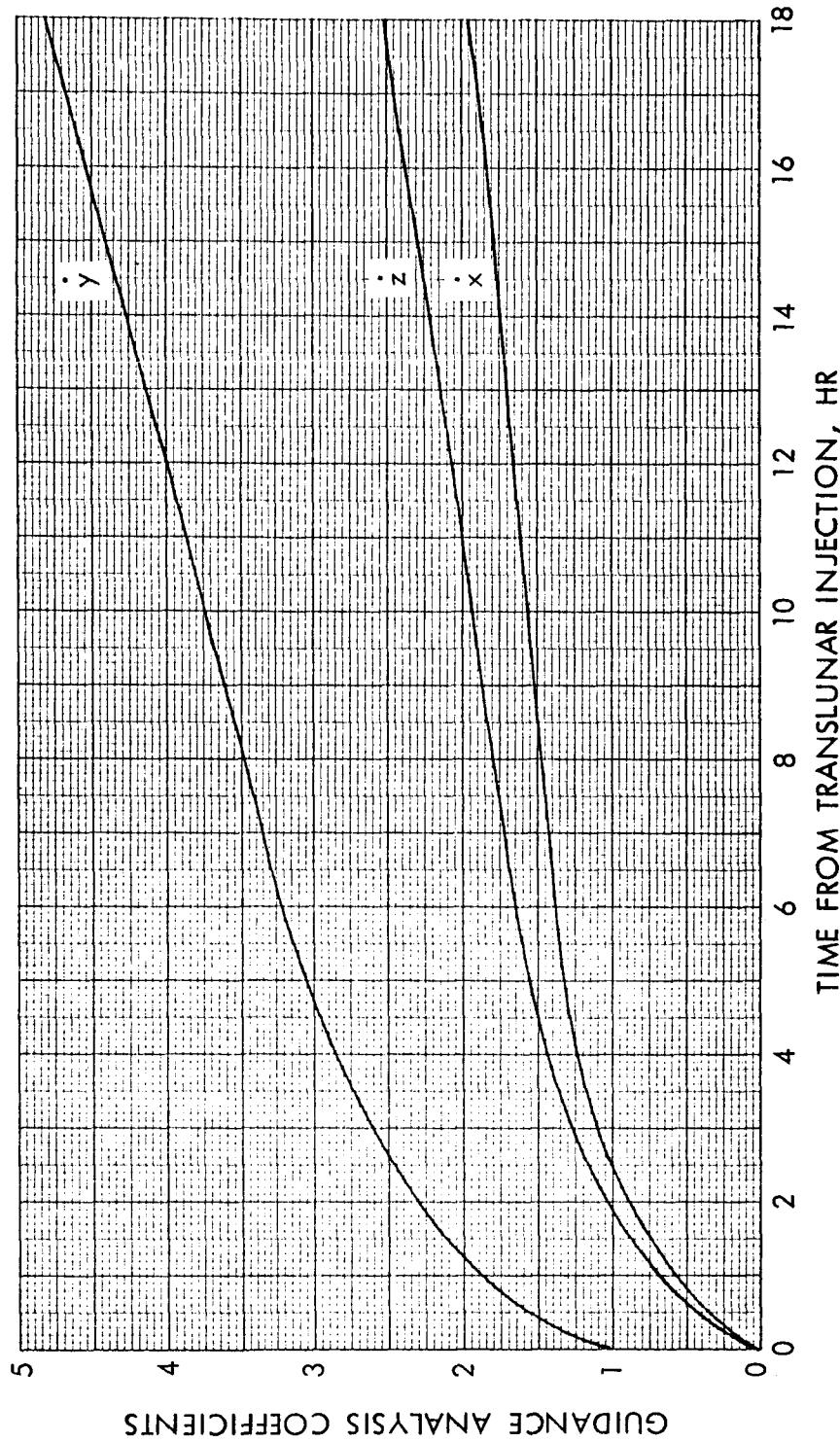


Figure 3.1-5. Translunar Flight - Partials of the Y Component of Midcourse Velocity with Respect to the Injection Velocity Components

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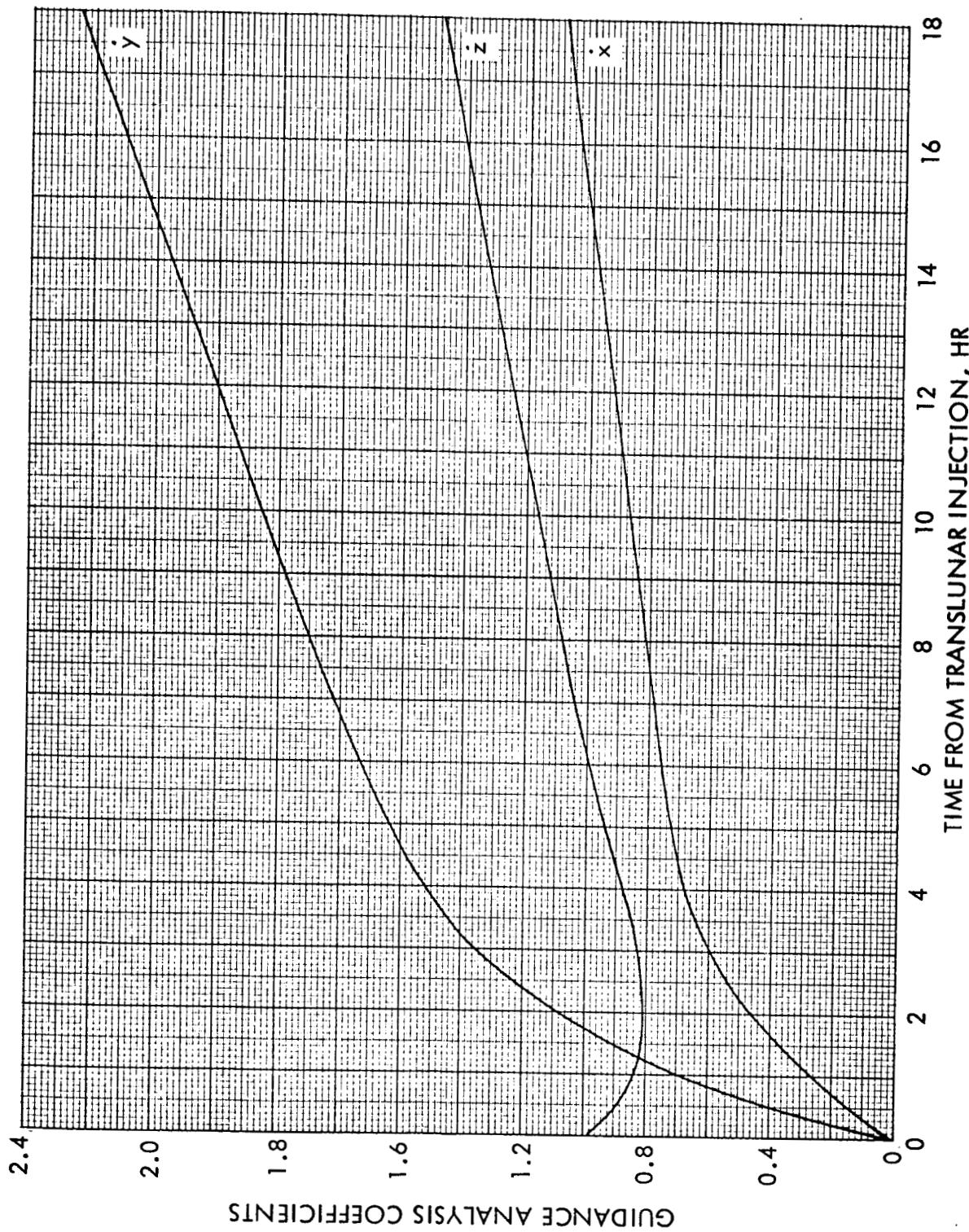


Figure 3.1-6. Translunar Flight - Partials of the Z Component of Midcourse Velocity with Respect to the Injection Velocity Components

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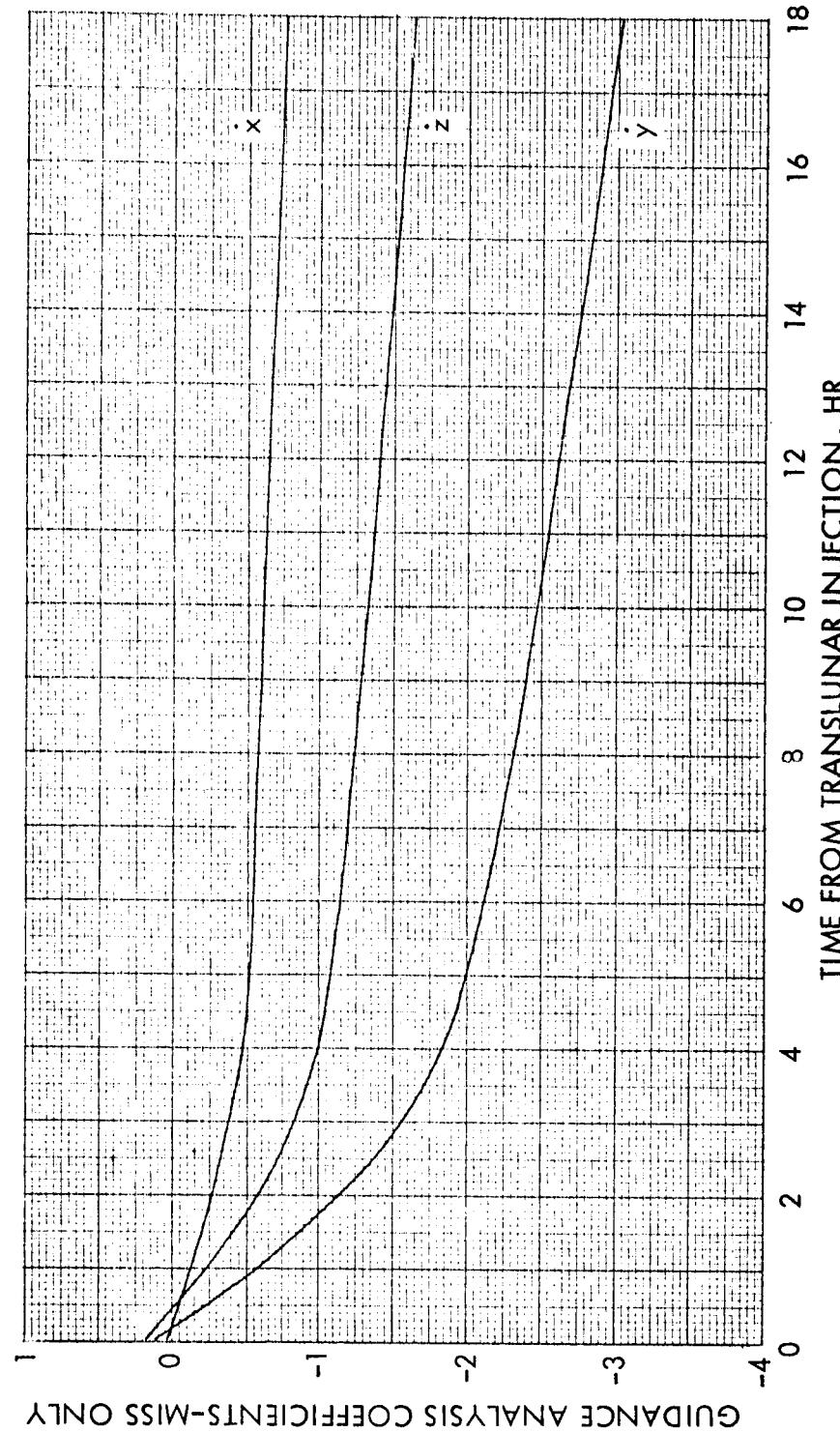


Figure 3.1-7. Translunar Flight - Partials of the X Component of Midcourse Velocity with Respect to the Injection Velocity Components

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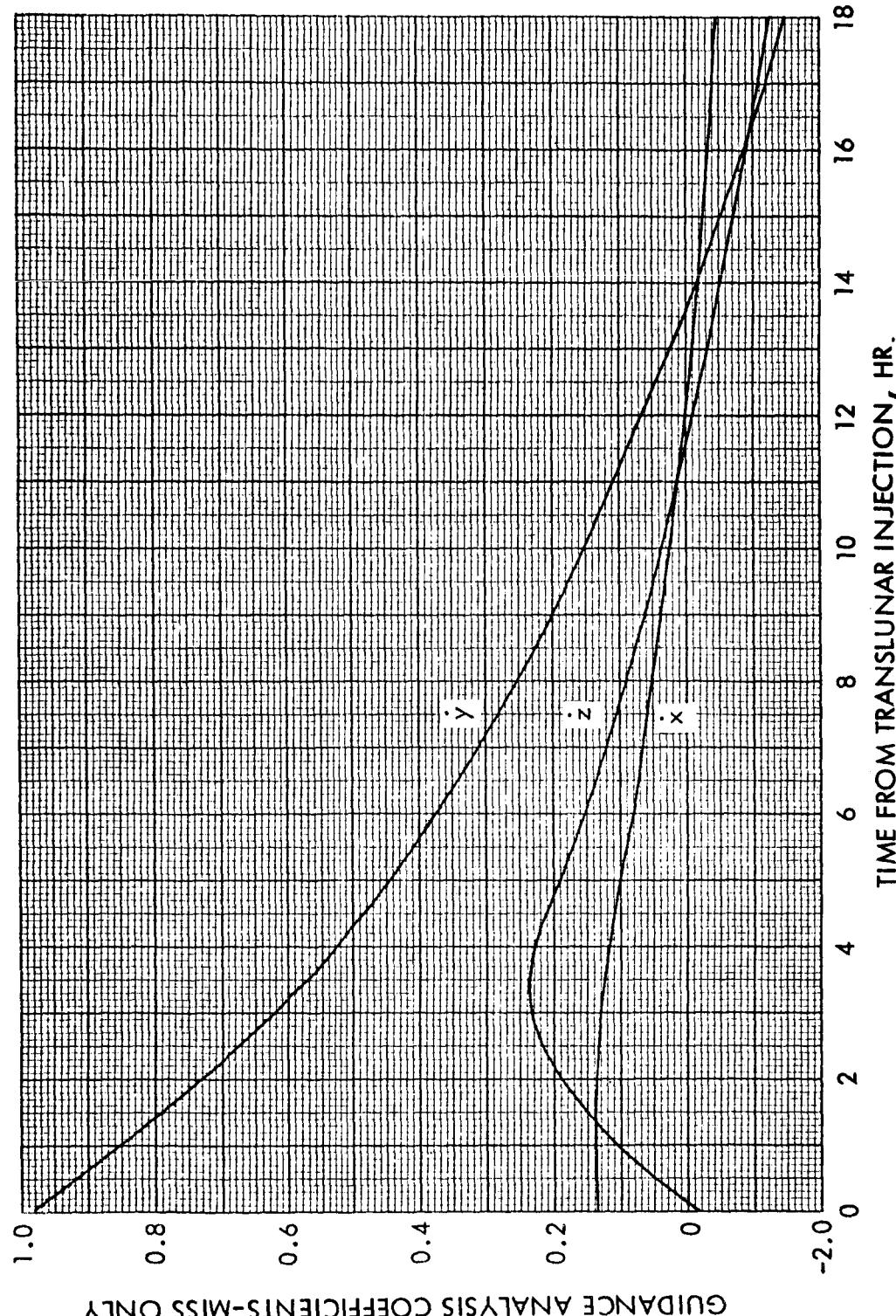


Figure 3.1-8. Translunar Flight - Partial of the Y Component of Midcourse Velocity with Respect to the Injection Velocity Components

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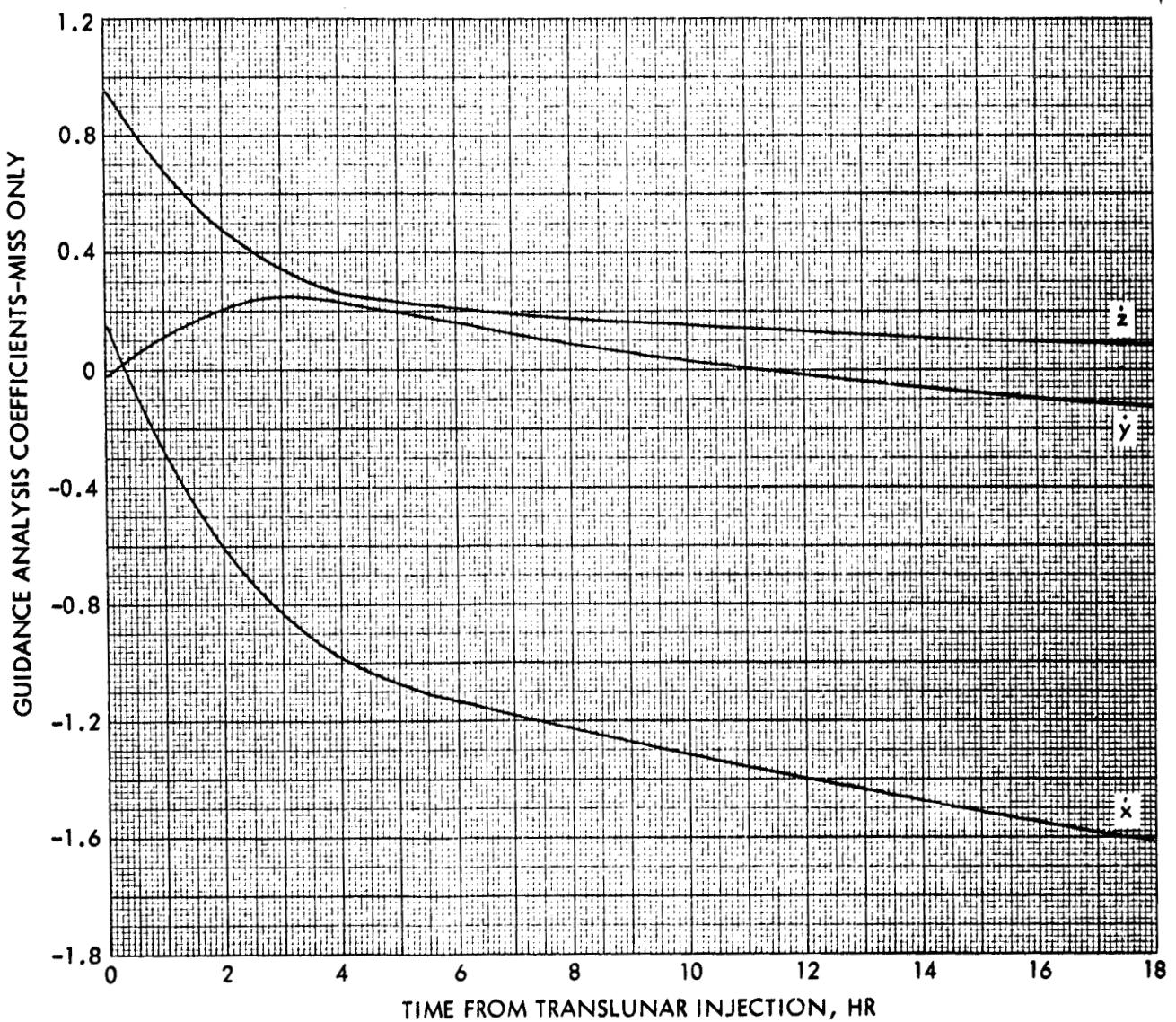


Figure 3.1-9. Translunar Flight - Partials of the Z Component of Midcourse Velocity with Respect to the Injection Velocity Components

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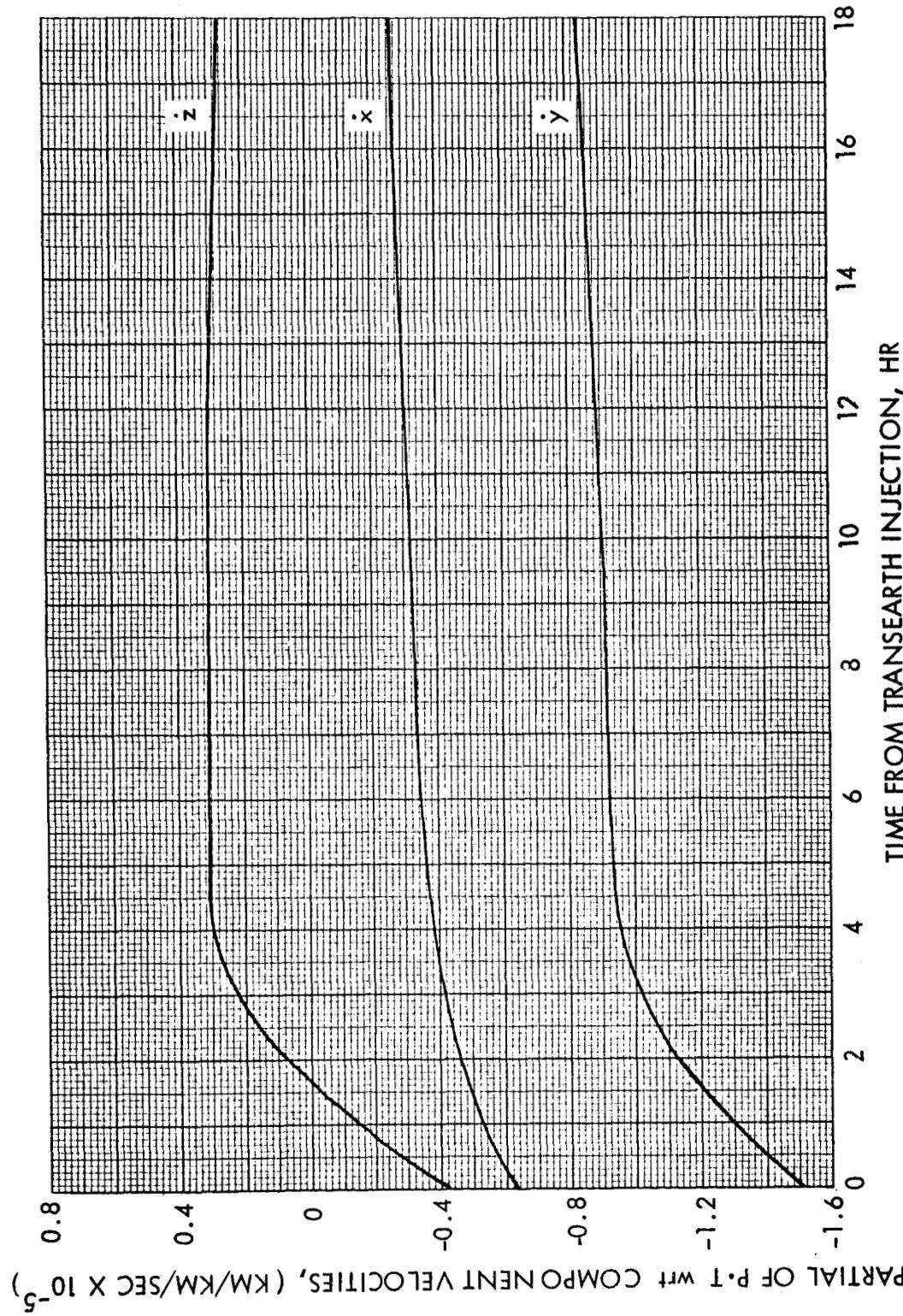


Figure 3.1-10. Transearth Flight - P.T. Midcourse Sensitivities

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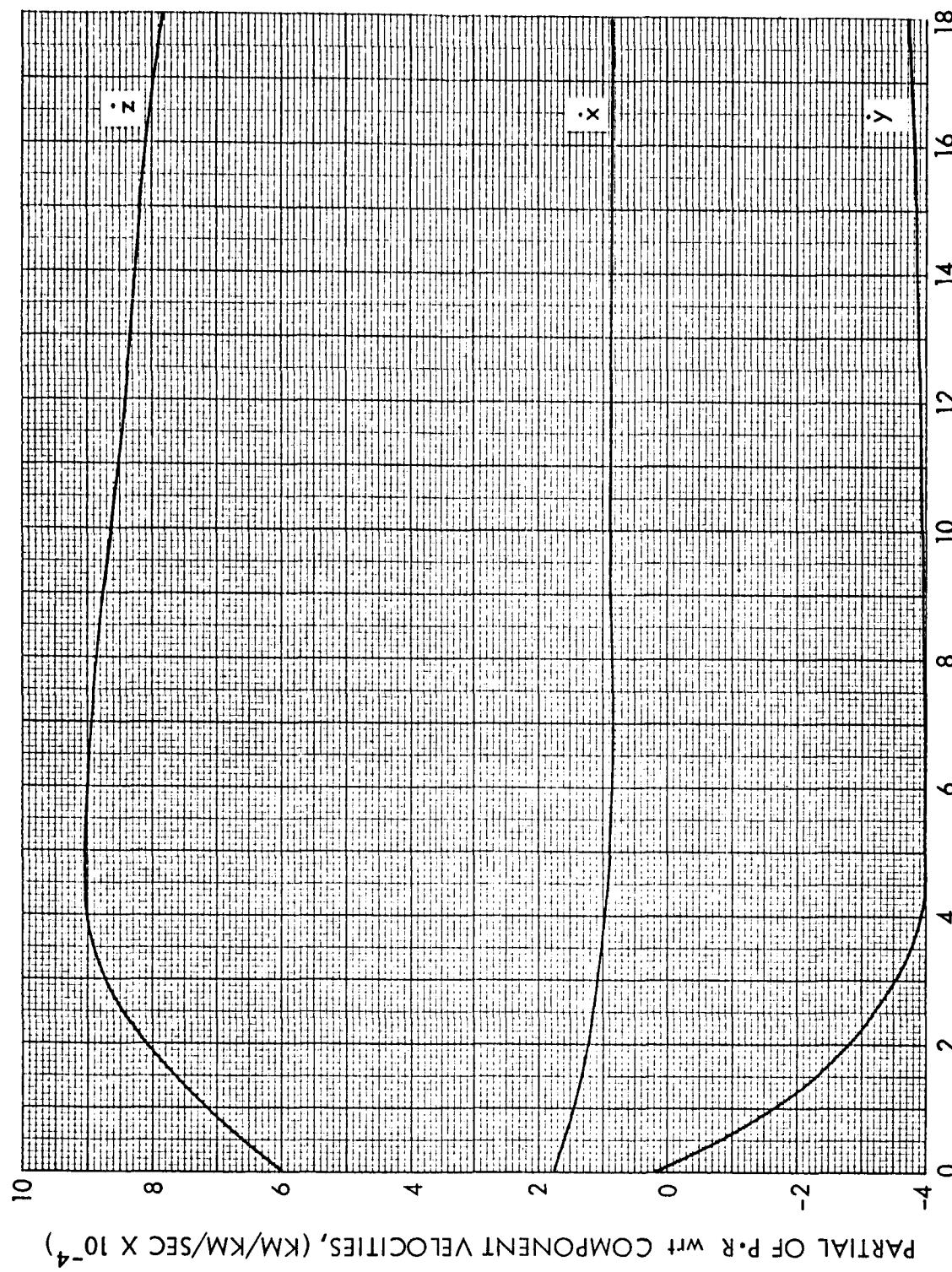


Figure 3.1-11. Transearth Flight - P. R Midcourse Sensitivities

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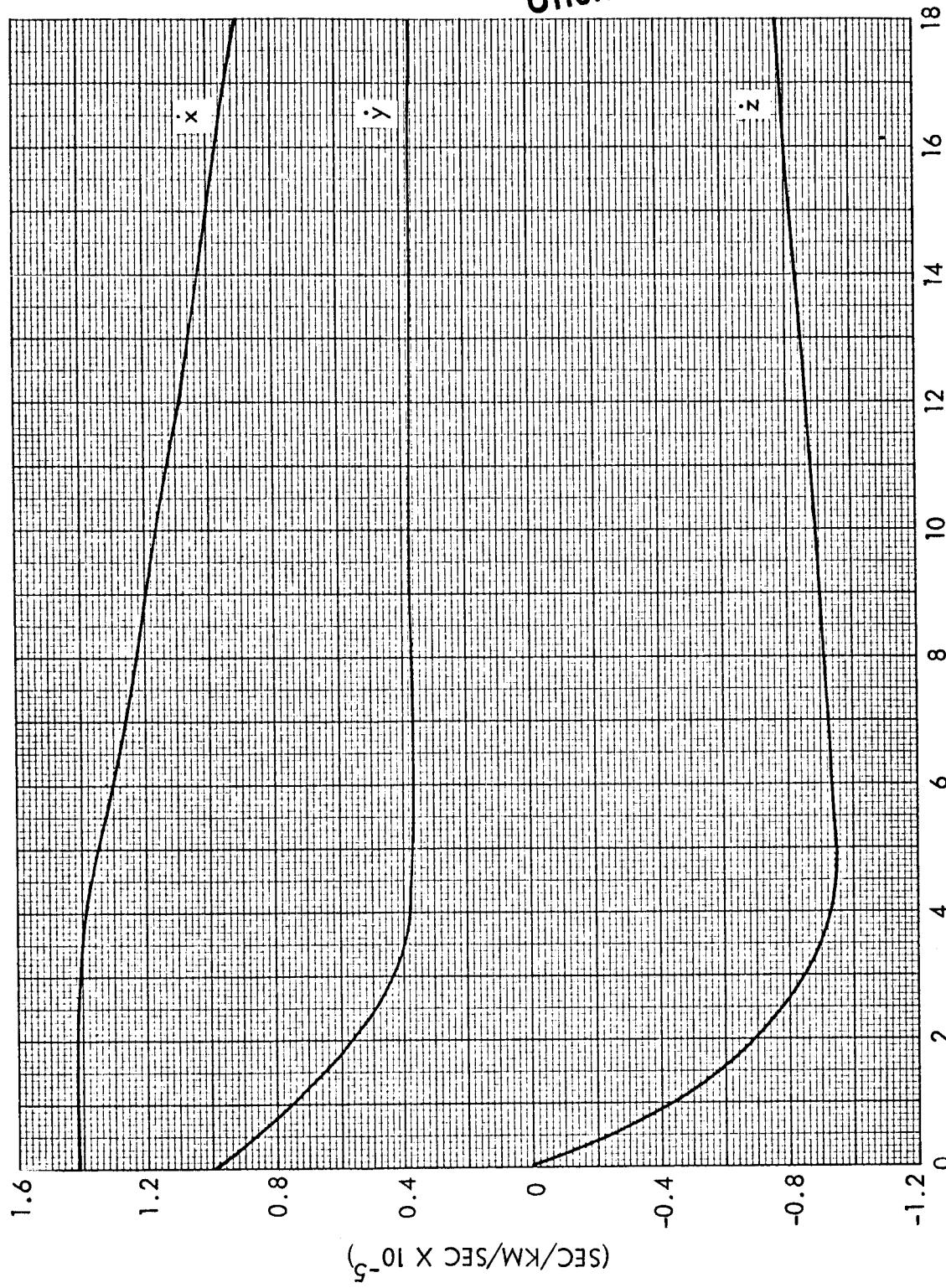


Figure 3.1-12. Transearth Flight - Time of Flight Midcourse Sensitivities

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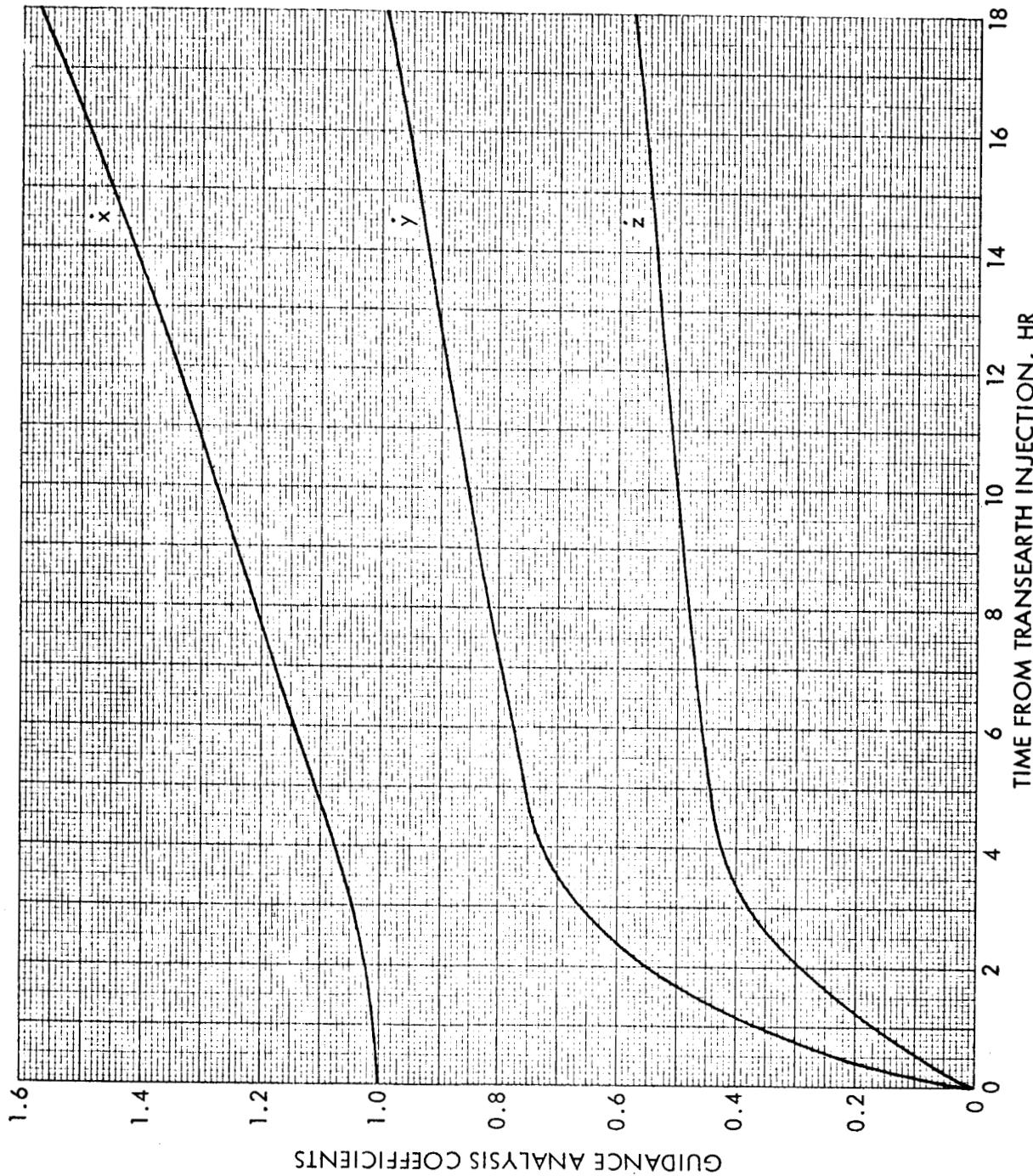


Figure 3.1-13. Transearth Flight - Partials of the X Component of Midcourse Velocity with Respect to the Injection Velocity Components

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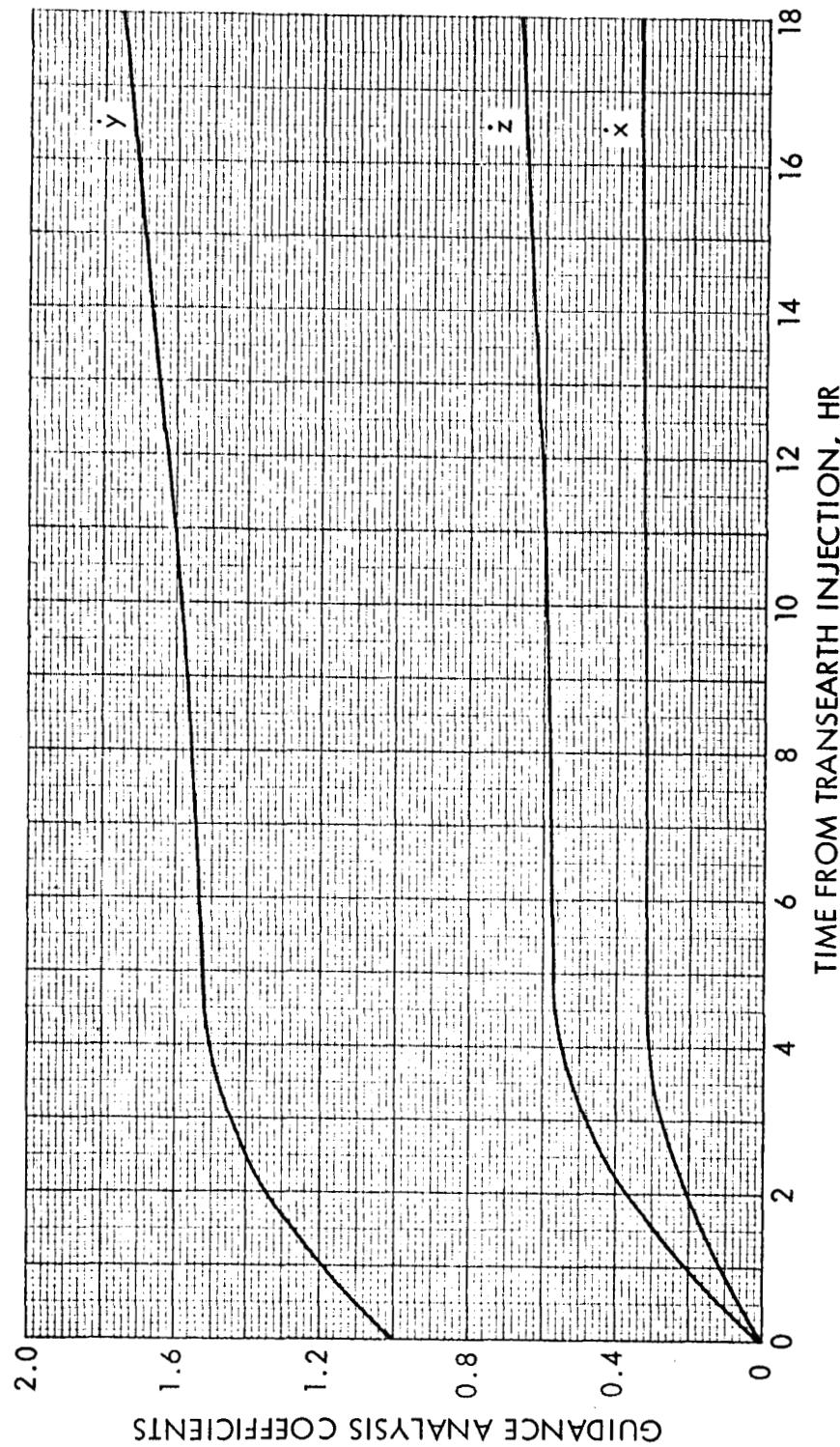


Figure 3.1-14. Transearth Flight - Partials of the Y Component of Midcourse Velocity with Respect to the Injection Velocity Component

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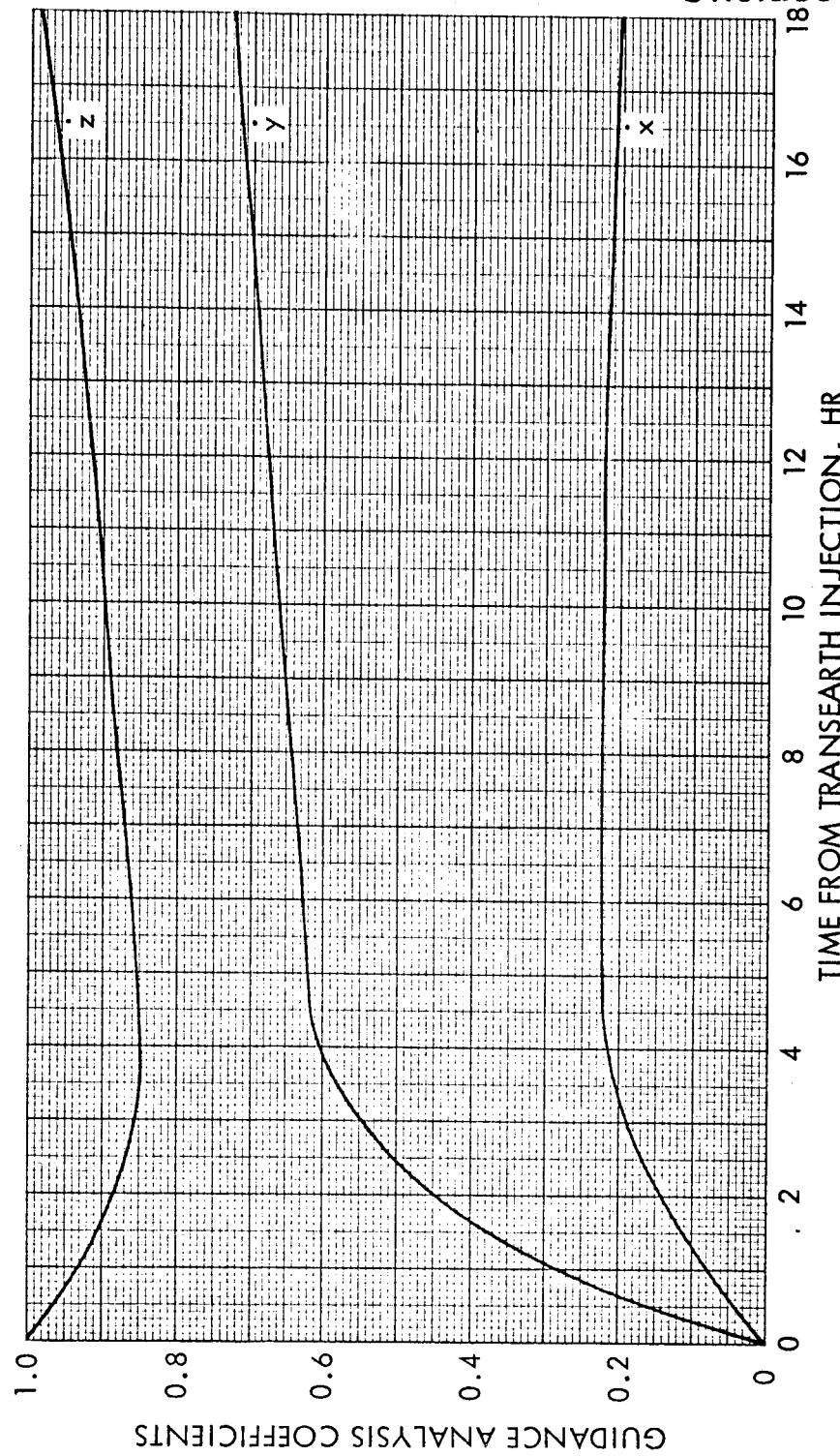


Figure 3.1-15. Transearth Flight - Partials of the Z Component of Midcourse Velocity with Respect to the Injection Velocity Components

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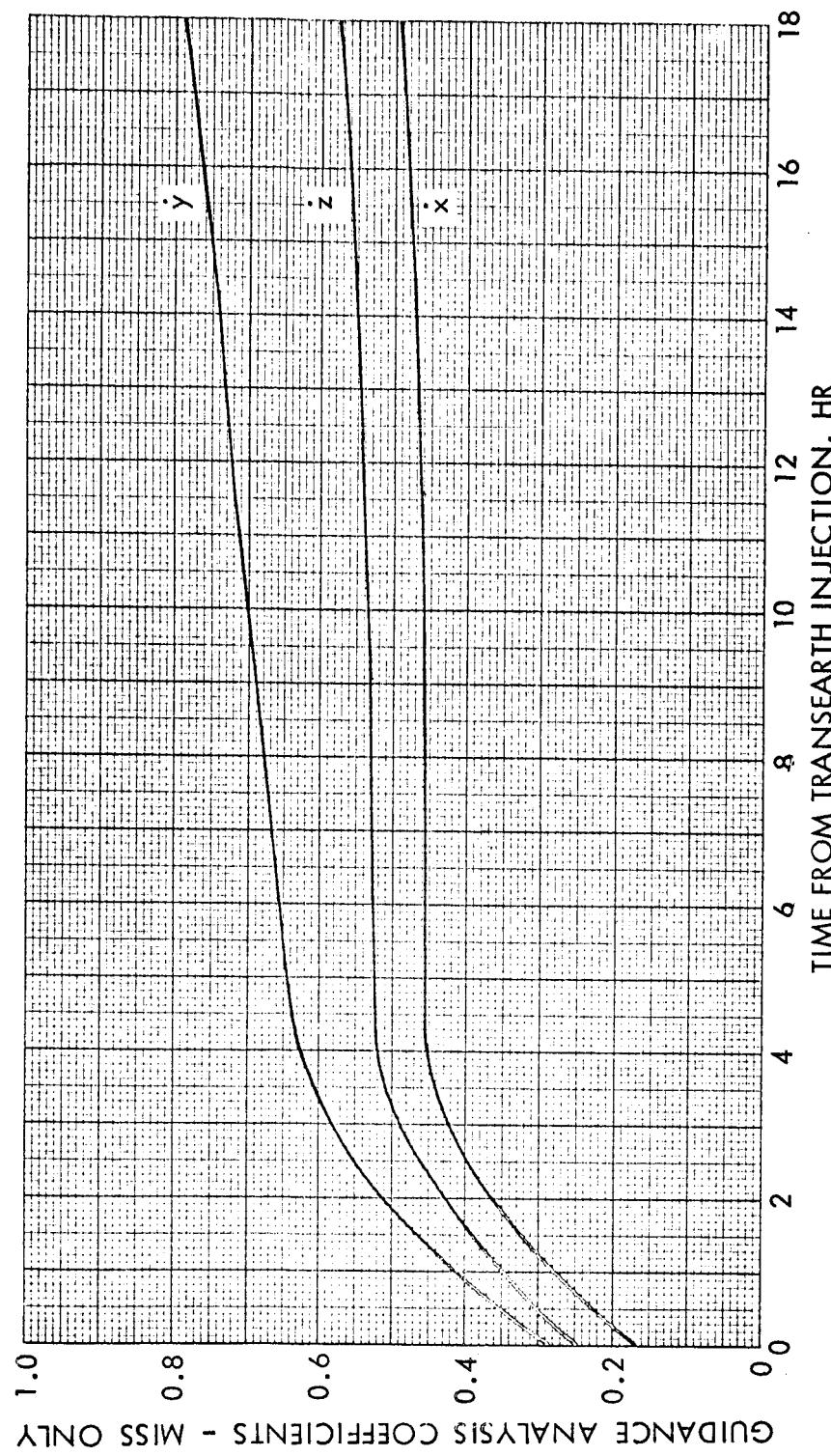


Figure 3.1-16. Transearth Flight - Partials of the X Component of Midcourse Velocity with Respect to the Injection Velocity Components

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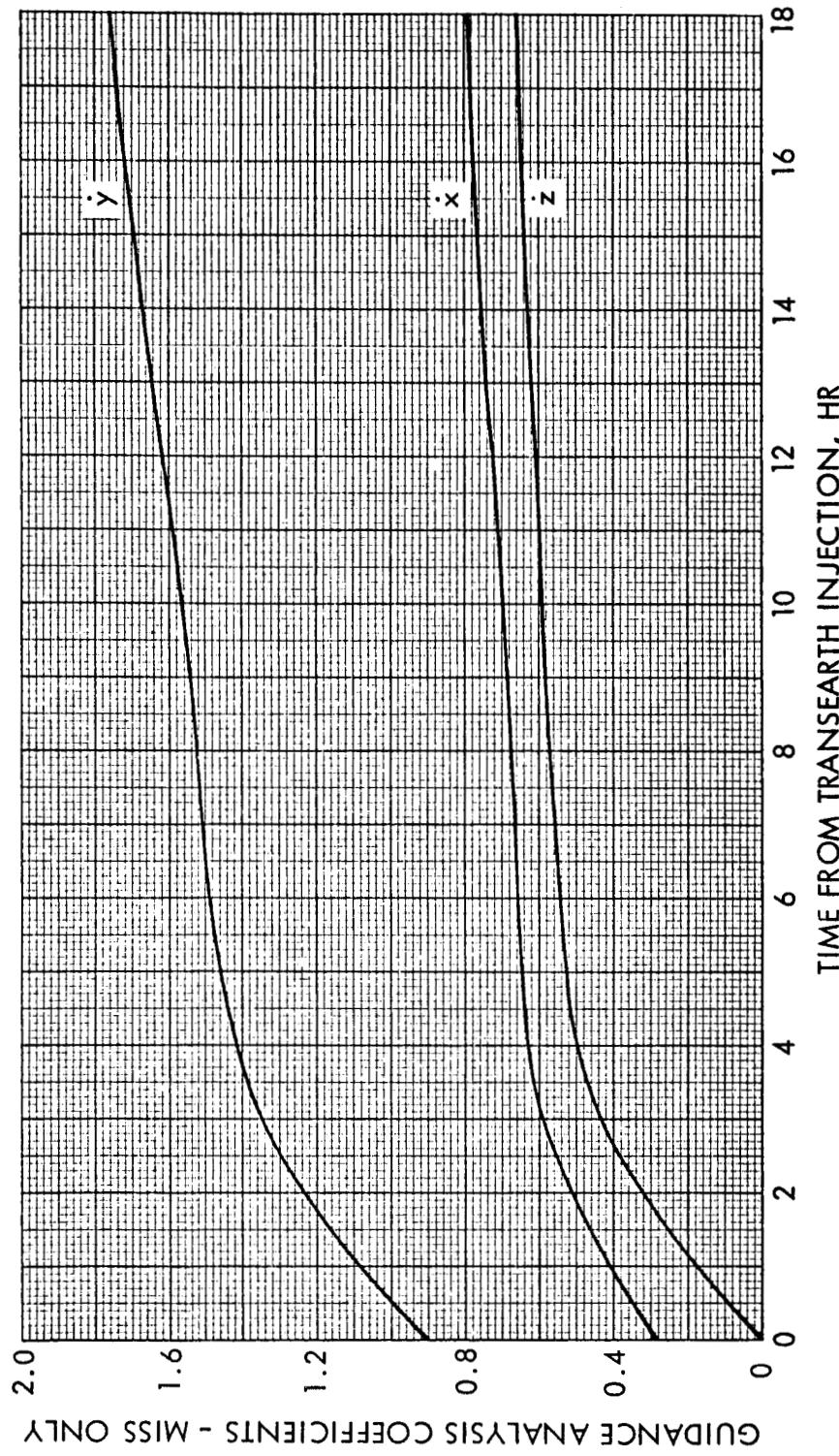


Figure 3.1-17. Transearth Flight - Partials of the Y Component of Midcourse Velocity with Respect to the Injection Velocity Components

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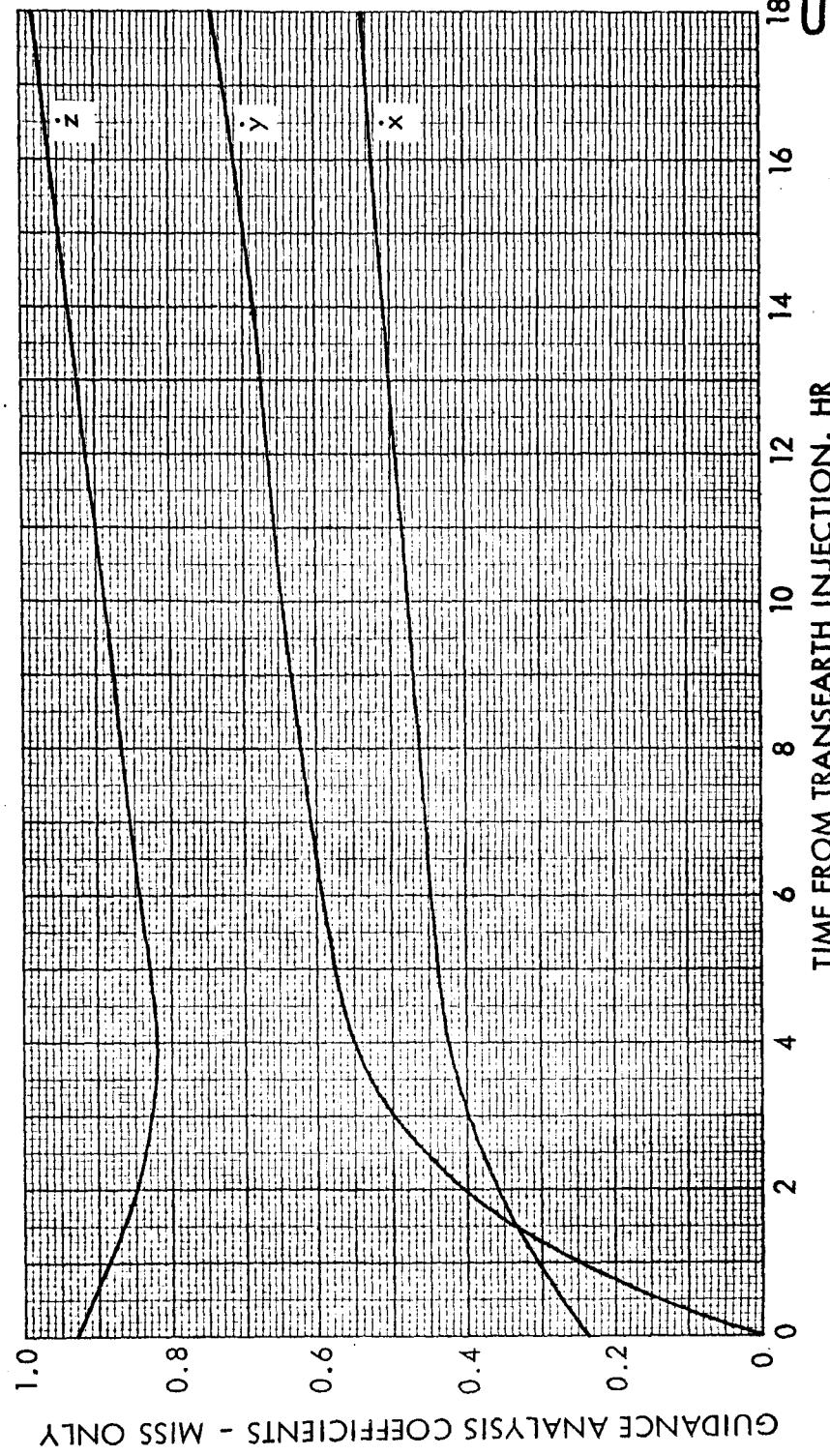


Figure 3.1-18. Transearth Flight - Partials of the Z Component of Midcourse Velocity with Respect to the Injection Velocity Components

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